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COMMERCIAL TRANSATLANTIC WIRELESS telegraphy was established on March 31. A London newspaper contracted with the Marconi Wireless Telegraph Co. for the daily transmission of news items from New York to London (via "wireless," Glace Bay to Poldhu). It is said that the contract price for this service was not much in excess of the rate for (cable) telegraphic messages between England and France.

AN EXPERIMENTAL OZONE WATER PURIFICATION plant is reported as to be built at Niagara Falls, N. Y., by the Atmospheric Products Co. Mr. D. R. Lovejoy is said to be actively connected with the enterprise.

AN ADDITION TO THE WATER FILTER PLANT of Lawrence, Mass., is proposed, and Chapin & Knowles, of Pittsburg, Pa., have been engaged as engineers therefor. Mr. Morris Knowles, Assoc. M. Am. Soc. C. E., of the firm named, was for a number of years a member of the Lawrence Water Board.

A SMALL WATER FILTRATION PLANT for Hartford, Conn., to supplement from the Connecticut River the present gravity supply, has been recommended by Mr. Allen Hazen, M. Am. Soc. C. E., 220 Broadway, New York City, and also by the water commissioners of Hartford. The filtration plant would have a nominal daily capacity of 5,000,000 gallons, and would include four covered masonry filters; besides which there would be a clear-water reservoir, pumping station, and a force main leading to the city. The estimated cost of these improvements is $302,000.

THE ITHACA TYPHOID EPIDEMIC, according to a public letter by Mr. Geo. A. Soper, Assoc. M. Am. Soc. C. E., 29 Broadway, New York City, numbered 681 cases and 51 deaths, so far as reported, up to March 29. The new cases reported diminished in March, and for the four days preceding the statement no new cases were reported.

THE COOLGARDIE WATER SUPPLY SYSTEM in West Australia, the longest pipe line for water supply in the world, is now in successful operation, delivering water from the reservoir in the Darling Mountains through a pipe line 30 ins. in diameter to a service reservoir at Coolgardie, 328 miles distant. In this distance the water is raised a vertical height of 1,447 ft. by pumping stations distributed along the line. The average rate of flow in the pipe line is about 2 ft. per second, and the capacity is about 5,000,000 gallons per day. The total cost of the entire work has been about $13,500,000 to the present time. Previous to the opening of this line the water supply of the Coolgardie district has been obtained by distilling the brackish water obtained in scant amount from wells, and it has been sold for about 2 cts. per gallon. The Coolgardie enterprise was fully described in our issues of Feb. 12 and 17 and Oct. 13, 1898. The credit for the success of the work is largely due to the energy and ability of the Chief Engineer, the late C. Y. O'Connor, who most unfortunately did not not live to witness the completion of his great project. After Mr. O'Connor's death, on March 10, 1901, the work was carried out by Mr. C. S. R. Palmer.

THE WATER-WORKS APPRAISAL case at Valparaiso, Ind., has been decided by the courts in favor of the city. The works were built by the Valparaiso City Water-Works Co. under a 50-year franchise, and a clause in the ordinance granting the franchises provided that at any time after 15 years from the completion of the works the city should have the right to purchase them at a value to be determined by "three disinterested hydraulic engineers." Under the provisions of this clause the city gave notice of its desire to purchase the works, but the company had no desire to sell and refused to appoint an appraised as required. The city therefore took the matter into the court, which itself had to act as appraiser. The company called as experts Mr. H. B. Smith, of Bay City, Mich. (of the Michigan Wooden Pipe Co.), and Mr. A. L. Holmes, of Grand Rapids, and they put the value of the works at $165,000. The city called in Mr. John W. Alvord and Mr. Daniel W. Mead, Mems. Am. Soc. C. E., both of Chicago, and their estimate of the value was $86,706. The court criticised rather strongly the estimate submitted on the part of the company and fixed the value of the plant at $86,706, adding $3,600 to the estimates of the city's experts. The value was given as follows:

Cost to reproduce	$89,617	
Depreciation	33,221	
Physical value	56,396	
Going value	26,710	
Present physical and going value, estimated by city's experts		$83,106
To this the court added:		
For meters	$750	
On intake	2,850	
Total price to be paid by the city		$86,706

A BILL AUTHORIZING THE SALE or lease of any municipal water-works, gas, or electric lighting plant in Pennsylvania, and giving any company acting under its provisions exclusive privileges as against both other companies and the municipality involved, has been suddenly and mysteriously introduced in the Pennsylvania legislature. No one will admit any knowledge of the real purpose of the bill, but there are fears that it is designed to prepare the way for the sale or lease of the Philadelphia water-works, now that the filtration plants are well under way. It is also suggested that the bill is merely designed to give some minor company or companies an indisputable monopoly on acquiring water or lighting plants now owned by cities and towns.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear collision between two passenger trains on the Southern Pacific Ry. at Lacoste, Tex., about 18 miles from San Antonio, Tex., on March 26. A train known as the Eagle Pass train had stopped at Lacoste for reasons unknown and was struck by the fast "Sunset Limited," which was traveling at high speed. The engine of the limited crashed through a caboose and sleeping car and the latter telescoped a private car. Three persons in the private car were killed and nine general passengers were injured.

WHILE TEARING DOWN A CHIMNEY at Mapleville, R. I., March 25, a heavy capstone fell. It crushed two 350-HP. boilers, permitting the steam to escape, and so damaged the chimney foundation that the chimney collapsed. Three men were seriously injured and the property loss was $10,000.

THE FERRYBOAT "BOUND BROOK," of the Central Railroad of New Jersey, was burned on the afternoon of March 30 while lying in her slip at Jersey City. The flames spread so rapidly that a half-dozen persons who were on board had to jump to the bow of a tug to save their lives. The boat was a nearly new double-deck vessel with steel hull, and the damage done by the flames was almost entirely to the wooden superstructure. The fire furnishes a new illustration of the exceedingly inflammable and dangerous construction in common use on American river and sound steamers.

A LAW AGAINST TALL BUILDINGS IN BOSTON has just been declared constitutional by the United States Supreme Court. In 1898 the Legislature of Massachusetts passed an act prohibiting the erection, on property fronting Copley Square, of any building to a height exceeding 90 ft., including buildings in course of erection at the time. The law was aimed at the Westminster Chambers, a building then being erected according to plans approved by the city authorities in the previous year. The Boston Museum of Fine Arts was mainly instrumental in having the law passed; it was claimed that the building, if carried to the height proposed, would cut off the light from the museum that was necessary for the full enjoyment of the works of art there exhibited. The State of Massachusetts brought suit, under the law of 1898, for an injunction against the Westminster Chambers to restrain it from completing the building and to compel it to take down as much of the work already erected as exceeded a height of 90 ft. This suit has just been decided on final appeal in favor of the state.

A CIVIL SERVICE EXAMINATION for the position of Aid in the U. S. Coast and Geodetic Survey will be held on April 21, 1903. The examination will consist of the subjects mentioned below, which will be weighted as follows:

Subjects.	Weights.
(1) Mathematics: Including geometry (plane and solid), algebra, trigonometry and the elements of calculus	10
(2) Practical computations: Involving the use of logarithmic tables	10
(3) Astronomy: Elementary questions in spherical and general astronomy, with special reference to detrmination of latitude, longitude and azimuth, and use of field instruments	10
(4) Physics: Elementary questions in optics, magnetism, etc.	10
(5) Surveying: Elementary questions in plans and geodetic surveying and use of field instruments	10
(6) Modern languages: Competitors may select one of the following: French, German, Spanish, Italian. Extracts of about 100 words are given for translation into English	10
(7) Drawing and descriptive geometry: A short test in topographic drawing and lettering is given with elementary questions on the principles of projection	10
(8) Educational training and experience (rated on Form 375)	10
(9) Physical condition (rated on Form 304)	20

The examination will be divided as follows: First day, 7 hours, first three subjects; second day, 7 hours, remaining subjects. Age limit, 18 to 25 years. From the eligibles resulting from this examination it is expected that certification will be made to fill twelve vacancies in the position of Aid in the Coast and Geodetic Survey, at a salary of $720 per annum each, and to other similar vacancies as they may occur.

TRACK FASTENINGS on American railways are severely criticised by Col. Yorke, of the British Board of Trade, in his report on American railways. He considers the universal use of spikes the weakest feature of American railway track.

RAILROAD EARNINGS FOR JANUARY, collected by the "Commercial and Financial Chronicle," show for 105 roads increases in gross earnings of 9.33% and increases in operating expenses of 13.34%. The increase in gross earnings was largely due to a marking up of freight rates on Jan. 1, and the increase in expenses is largely due to increased wages and higher prices for materials.

RECORDS OF CAR MOVEMENTS on the New York Central & Hudson River R. R. were broken on Feb. 10 last, when 26,085 freight cars were moved in 24 hours. Of these cars 16,605 were loaded and 9,840 were empty. On the same date the Lake Shore & Michigan Southern Ry. handled 10,915 loaded cars and 3,315 empties, a total movement of 14,231 cars, or a total on both lines of 40,316 cars.

WELDING ALUMINUM is said to be successfully accomplished by a process recently developed in Germany. Hitherto the difficulty in welding this metal has been that it becomes brittle and "rotten" when approaching its melting point, but it has now been found that there is a temperature, just below incandescence, where the metal softens sufficiently to make sound welds possible. As the metal does not oxidize at this temperature, no flux is required. It is said that with careful working welds may be produced which cannot be detected by the eye and which are equal in strength to the body of the bar.

TUNNEL AT MICHEL CREEK LOOP, CROW'S NEST PASS LINE, CANADIAN PACIFIC RY.

By C. R. Coutlee, M. Can. Soc. C. E.*

A tunnel through loose gravel has recently been completed at a point known as Michel Creek Loop, on the new Crow's Nest Pass Line of the Canadian Pacific Ry. This work involved difficulties in construction, and a brief description of the methods and plant will be of interest to engineers.

A description of the Crow's Nest Branch of the Canadian Pacific Ry. appeared in Engineering News of March 10, 1898, and two tunnels were mentioned as occurring just west of the Rocky Mountain summit. Although these tunnels were attempted, "cave-ins" happened at each, and there was no time to complete them during construction, so temporary lines were built around each. The "Loop" tunnel was the more important of the two, and to pass it an interesting "shoo-fly" line was substituted. This necessitated two pile trestles, each about 50 ft. high, and a long cutting in "gumbo" 50 ft. deep, which defied all attempts to keep it clear of slips in wet weather. Through the western part of this cut and out onto one trestle there was originally a 20° curve through 160° of arc, but slips and slides had sharpened it to 25°, and even to 28° in places. Around the inside an inner rail was spiked to act as a guard, and it is interesting to note that compound engines constantly passed over it, yet only once in two years was there a derailment. No elevation was given, and, although the outside rail wore considerably, it seemed to remain constant after a certain amount had taken place. Trains of 20 to 30 cars frequently passed, and once a train of 60 cars was hauled over this curve. The grade was level. Passenger car platforms jammed somewhat, and two vestibule cars were not coupled together lest the side door glass should break, but couplers never became detached. A water jet from the locomotive, to wet the rail, aided much in operating and prevented squeaking.

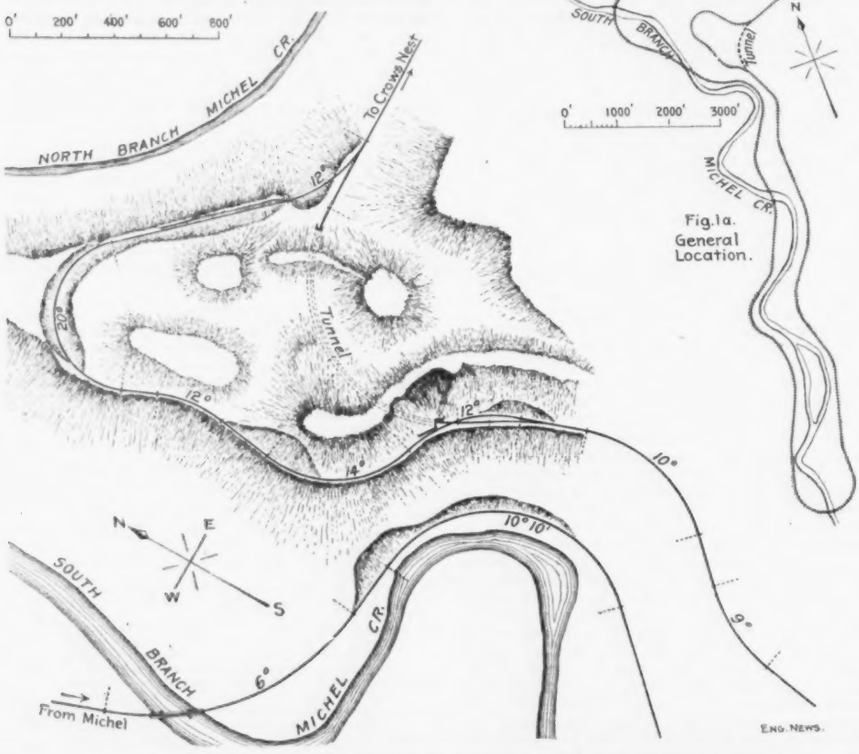

FIG. 1. MAP OF MICHEL CREEK LOOP, CANADIAN PACIFIC RY., SHOWING LOCATION OF TUNNEL.

The location of the tunnel and the "Loop" itself is shown by Fig. 1. Just east of the tunnel the line leaves the rocky canyon of the North Michel, but it is 200 ft. too high to follow the Main Michel, and so has to "side-hill" along the glacial drift until it is sufficiently low to turn and descend along the bottom of the valley. The maximum grade is 1%, and the Michel falls at this rate for six miles further to the coal mines of that name.

The tunnel location was practically confined to a line outside the old workings. Originally the alinement was an 8° curve, but the "cave-ins" at each end had spoiled the ground and the old portals could not be approached within 50 ft., so a good wall of firm soil could be secured against the old workings.

At the west end the failure resulted in a slide of the whole hill face, which denuded it of trees and roots and caused a running gravel face. The wind blew away the sand and the pebbles rolled down the hill face onto the track, which passed close along the bottom of the slope, so that watchmen were required day and night to shovel the track clear.

At the east end the old tunnel was still open for 60 ft. in. It seems to have been driven full area, 16 ft. wide and 21 ft. high, for about 3 ft. forward at a time, main frames were then set up and 4 × 6-in lagging bridged back to the last frame placed and packed over with wood. The frames were 12-in. × 12-in. fir spaced 3-ft. centers, the arch being of five pieces resting directly on the top of side posts. Dependence seems to have been placed upon the frost to solidify the ground at night enough for the next day's drifting. This old working was filled with earth from the new tunnel.

WORK FROM EAST END.—The present work began at the east end in March, 1901, and only a short entrance cut was required to face up, as the hill face was very steep. The method of driving was to take the excavation out in two lifts (Fig. 2). The bottom lift or bench was run in 21 ft. wide, with vertical sides, until a cut of 15 ft., the height of wall plate, was reached. An upper cut was meantime run in at the grade of the wall plate until a face 8 ft. high was obtained. Into this upper face two drifts (Figs. 2 and 3), 8 ft. high and 6 ft. wide, were driven, one at each side, leaving about 8 ft. of earth between. When these side drifts had advanced about 20 ft., a wall-plate was accurately set for line and level in the outer side of each and securely blocked to place. A crown drift (Fig. 3) was then driven at the level of tops of the side drifts and extending 4 ft. above them. This connected the side galleries, so that the roof lagging of each could be broken through and the arch of 12-in. × 12-in. timber set up upon the wall-plates. The wall-plates were 9.5 ft. from the center line of the tunnel, and were set as chords of the curve of each wall; the outside plate was 20.3 ft. long, and the inner one 19.6 ft. Each plate was a 12-in. × 12-in. timber, shaped on top to fit a "crow-foot," and bored at 15-in. intervals for dowels. The lower segment of the arch on each side had one end cut to a broad V-shaped notch or "crow-foot" to saddle the wall-plate. The other arch joints were plain miters. No difficulty was found in framing these accurately to templet by ordinary cross-cut sawing. Two carpenters did the framing and a foreman and three timbermen set the arch frames up. Dowels of ¾-in. round iron 6 ins. long were inserted in each joint. The arch sets were spaced only 3 ins. apart, and the wall posts, inserted beneath the plates, as the lower bench advanced, were also spaced 3 ins. throughout the entire 900 ft. in length of tunnel.

The details of driving the side drifts through the very loose gravel, which proved to be the material all through, is interesting. First a frame of 8-in. round mountain fir was prepared (Fig. 3). The sill, 6 ft. long, was set accurately to the elevation of the under side of the wall-plate, as upon it the plate rested, to secure thorough support. The posts were about 8 ft. long, the outer one battered more than the inner, and the cap, 4 ft. long was flatted and gained down 1 in. upon the post to form a small shoulder and thus prevent the sides squeezing in. The drift frame being set up, the face in front was walled up with 1-in. breast boards, braced with inclined struts. All around the outside of the frame close lagging was now entered and driven forward into the face by sledges. Scantling of 2-in. × 4-in. mountain fir in lengths of 5 ft. was employed throughout as tamerac and other woods proved too brittle to resist the pressure of the loose gravel. Each piece was first driven about half-way with an upward and outward lead, and so as to form a close longitudinal joint with its neighbors. In this way a hood of horizontal sheet piling was secured for over 2 ft. in advance of the breast boarding. The headingman now carefully removed the top breast board and was met with a shower of gravel, but the flow was staunched by pushing the board ahead about 2 ft. and wedging it to place. Then the next board below was removed, and so on down to the bottom of the drift, so that the whole breast wall was advanced to the limit of the hood. The lagging was now acting like a cantilever, extending forward from the drift frame, except for the precarious support given by the breast wall boarding. To afford secure bearings, a false frame was set up consisting of round timber like the full frame, but somewhat lighter. Then the lagging was driven forward its full length and the breast wall advanced as before, when a second true frame was placed, which was about 4 ft. from the first one.

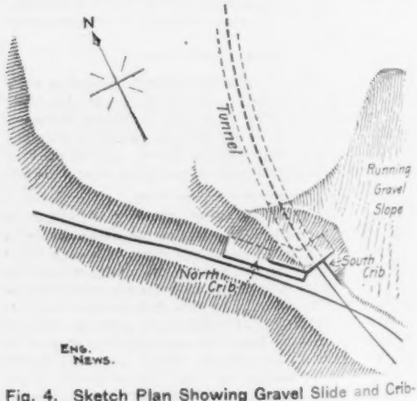

Fig. 4. Sketch Plan Showing Gravel Slide and Cribwork at West End of Tunnel.

*Inns of Court Building, Vancouver, B. C.

To drive new lengths of lagging ahead from this frame would have been impossible if the ends of the last lot had rested tight against the drift frame. The almost fluid pressure of the gravel was too great to allow of inserting lagging and wedging out that already driven, but the upward and outward flare given in driving brought the points about 4 ins. outside the forward frame. This space outside of posts and caps was filled by a bridge of 2-in. scantling blocked off the frame by 2-in. blocks. New lengths were inserted beneath the bridge and driven forward, then the above-described operations were repeated. Considerable friction was encountered in driving, and only good mountain fir scantling stood the sledging and pressure.

The crown drift or top heading (Fig. 3) was advanced in a similar manner, but the cap being longer, about 8 ft., it required middle props. The top drift being only 4 ft. high, the working space was much restricted.

The work of the headingmen was arduous. Over 50 pieces of lagging 4 ins. wide were required to sheet around each drift, and every piece had to be driven with forcible blows, often in awkward positions, and always by candle light. Two headingmen were employed at the face of each side drift and three in the crown drift. While one was driving, the other, with a small steel pinch-bar, guided the lagging and prevented it from twisting.

Although, fortunately, no springs were met with, yet the gravel was frequently very wet and the workmen were kept drenched with the cold drip. When boulders obstructed the lagging they were sometimes worked out carefully by bars, but if large they had to be broken by plug and feather, as powder could not be used for fear of wrecking the drift and letting in a run of gravel. Lumps of float coal were occasionally found.

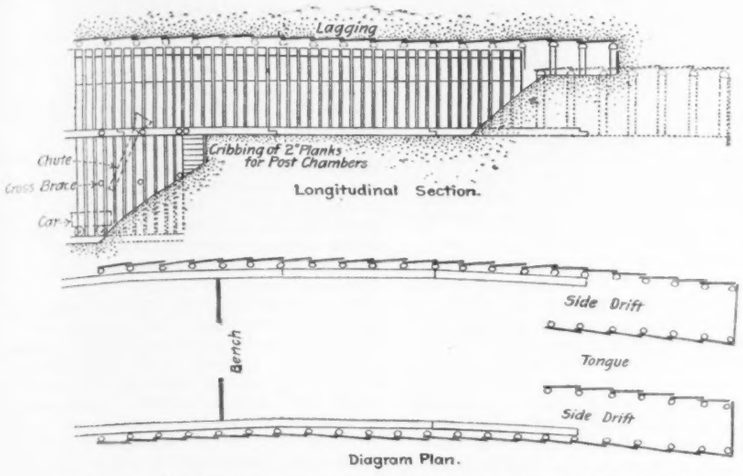

FIG. 2. LONGITUDINAL SECTION AND PLAN SHOWING METHOD OF DRIVING TUNNEL.

The earth accumulating at the face of the drift was loaded into barrows and wheeled out by muckers from time to time. These men also handled the material from the crown drift and excavated the tongue (Fig. 3) beneath the crown drift and between the side drifts. All excavation for the upper part was wheeled out and dumped down through chutes (Fig. 2) into small cars, which were hauled out by horses at grade level.

The exposed face of the lower lift or bench was kept breast-boarded at each side, but the central portion was allowed to assume a slope. Round timbers 6 ins. in diameter were placed horizontally across the tunnel between the wall-plates at intervals of 5 ft. (Fig. 2), and another tier 7 ft. lower. Against these poles the boarding up or "cribbing" at the sides was braced. They also served to keep the sides from squeezing together while the earth was taking its "set."

In excavating post chambers, the top breast board was removed and the gravel scraped away sufficiently to set it forward about 3 ft. A side board was then inserted parallel to and just outside the wall-plate to prevent side runs. In this manner a revetted chamber was cribbed down to grade at each side. At grade, sills 12 ins. x 12 ins. x 2 ft. were set, then a post was entered under the wall-plate and resting upon the sill. The bottom of the post was then jacked out, sliding upon the sill until the post was plumb. Norton jackscrews were used, heeled against the middle part of the

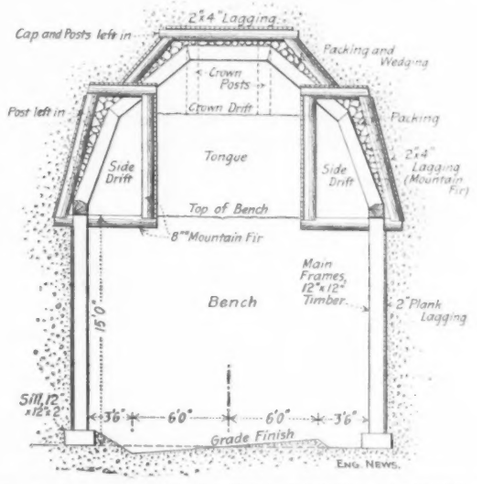

FIG. 3. TRANSVERSE SECTION SHOWING METHOD OF EXCAVATING AND TIMBERING.

bench, which projected between the post chambers. Great force was required to squeeze the post beneath the wall plate, but a tight fit was secured. While excavating the post chambers, the unsupported wall-plate formed a bridge about 3 ft. long from the gravel of the bench to the posts already set. Generally a space for two posts was excavated, but sometimes the ground was too loose and only a chamber sufficient for one post could be taken out at a time. Great care was taken to prevent the wall-plates from sagging under the weight of the roof before the posts could be inserted. The loose gravel of the bench would often have failed had it not been for the sill timbers of the drift frames upon which the wall-plates were originally laid. A temporary support for the roof was secured by wedging posts between the roof cap and the top of the bench, and thus the weight on the wall-plates was reduced. Upon the top tier of cross poles a platform and wooden track was laid so as to bring in timber for the roof arches and the drifts.

The composition of the force employed, with wages paid, was about as follows:

	Day (11 hrs.)	Night (11 hrs.)	Rate per hour.
General foreman	1	1	$0.40
Timber foreman	1	1	.35
Headingmen, north drift	2	2	.325
" south "	2	2	.325
" center "	3	3	.325
Benchmen, north side	2	2	.30
" south "	2	2	.30
Timbermen erecting sets	3	..	.30
Carpenters framing outside	2	..	.35
Blacksmith	1	..	.35
Muckers	11	6	.225
Teamsters	2	1	.20
Horses hauling timber, etc.	2	..	.20
Car horses	1	1	.20

A fair advance per week was 21 ft. at one end. From April till November, 1901, when the headings met, there was no cessation of work day, night nor Sundays, but both ends were not continuously worked. The cost was divided about as follows; length 900 ft. lined with 12-in. x 12-in. fir sets placed 3 ins. apart:

Labor	$56,000
Timber	11,000
Supplies	3,000
Total	$70,000

This, including the frame portal at the east end and the cribwork at the west end, made the cost of the tunnel about $77 per lineal foot.

Nearly a million feet of timber was used, of which the 12-in. x 12-in. main sets amounted to 550,000 ft. B. M. The 2-in. x 4-in. lagging amounted to 130,000 ft. B. M., and there was about 135,-

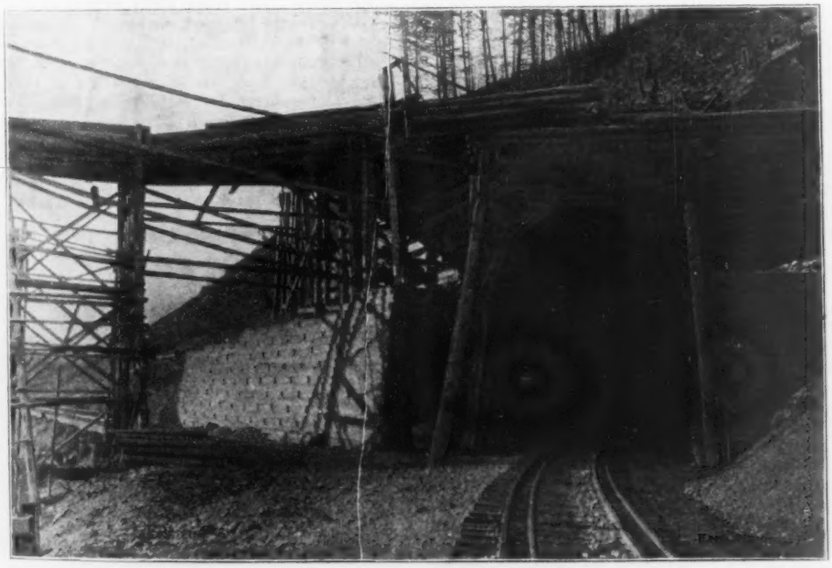

FIG. 5. VIEW OF CRIBWORK AT WEST END OF TUNNEL.

000 ft. B. M. of boards and planks for lagging behind side wall posts and for breast boarding faces. Wedges 1 ft. long and 2-in. x 4-in. at butt were largely used to keep the laggings in place, behind side posts and in drifts; their number amounted to 130,000. All the timbers, scantling, wedges and boards were of tough mountain fir, furnished by Leitch Bros., of Cranbrook, B. C., 100 miles distant, the general price being $10 per M.

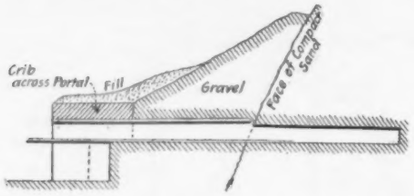

Fig. 6. Sketch Profile of West End of Tunnel.

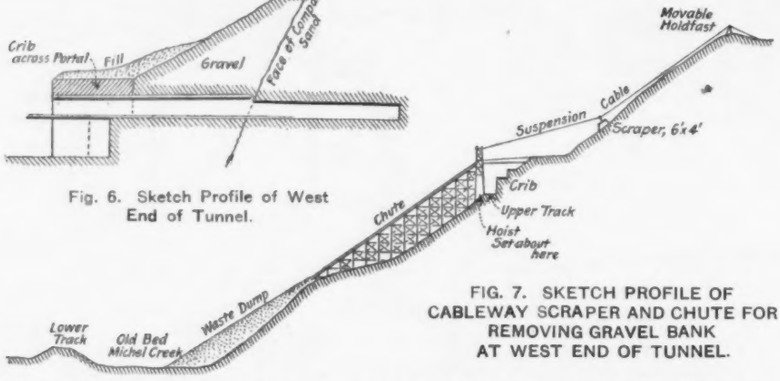

FIG. 7. SKETCH PROFILE OF CABLEWAY SCRAPER AND CHUTE FOR REMOVING GRAVEL BANK AT WEST END OF TUNNEL.

As each roof frame was set up, the space above, between it and the drift lagging, was closely packed with blocks of wood 12 ins. to 15 ins. in length. These were fitted to place over the main timbers and then wedged with smaller pieces to secure a thoroughly tight packing. The cost of tools and supplies was small; the candles used amounted to four tons. The mucking cars were simply and easily constructed and suited admirably for mountain conditions. The top of box was not too high, a great advantage where loading is done by shovellers.

WORK FROM WEST END.—The chief difficulty in construction was encountered at the west end. The axis of the tunnel intersected the contours of the hill face at about 55°. This meant that one side of the tunnel was receiving the pressure of the hill before the opposite side had entered sufficiently beneath the ground to receive any counter-pressure to hold it in place. To supply a buttress for the unsupported side, a crib was built for 80 ft. along the toe of hill and 20 ft. wide, the height being 15 ft., or up to wall-plate level. A smaller crib was also construction on the inside and between these two the hill was faced up (Fig. 4). Drifting was then begun and carried on as described for the east end.

Immediately, however, the side thrust of the hill became manifest. The side drift frames buckled sideways so that diagonal bracing had to be resorted to and the round timber caps crushed to half their thickness upon the posts. Everything was at high pressure, the lagging cracked and extra side drift frames had to be set up. The main timbers were placed as soon as possible, but they were thrust over 6 ins. before the slip stopped. About 70 ft. in from the west face, however, a hard sand knob (Fig. 6) was entered and the trouble ceased.

The loose gravel hill face seems to have slipped downwards along this hard sand and at the same time across the line of tunnel, twisting everything until it packed itself behind the large crib, which stood firm. The side pressure distorted the roof segments and opened the miter joints on the up side, while the longitudinal component of the pressure set the frames outwards on top for the whole western 100 ft. of the tunnel. Only the upper lift was carried through to a junction with the east end drifts, which took place in November, 1901. Work was stopped on the lower lift and the roof was strongly shored up and braced for the 100 ft. affected. In January, 1902, it was decided to remove part of the hill face that caused the skew pressure.

To accomplish this a cable scraper (Fig. 7) was set up. A standing, or suspension cable, of 1½-in. wire rope was secured down hill to a round timber tower about 50 ft. high. The up-hill end was attached to a moveable "holdfast," which allowed of swinging the cable laterally, with the tower as the center. Upon the suspension cable was a traveling block from which a boiler-plate scraper pan 6 ft. wide was suspended. At the front and rear of the scraper a ½-in. wire rope up haul and down haul was attached by a bridle arrangement. At the foot of the tower there was a steam hoist to one drum, of which the suspension cable was led by suitable blocks. This allowed of raising or lowering the cable with traveling block and scraper by winding on or off the drum, consequently the "bite in" of scraper or its feed, as it descended the hill slope, was under control. The up and down haul lines were also led to hoist drums.

A V-shaped gulley for the pan to run in was first made by blasting out stumps and frozen earth, after which the sides were picked down by men to furnish loose material to the scraper. Besides filling itself, the scraper pushed down a large load of gravel, thus carrying down 4 to 6 cu. yds. per trip. At the tower the pan emptied into a plank chute 6 ft. wide, with 1-ft. sides. The inclination of this chute was 1⅛ to 1, which was enough, except when the gravel was wet from snow or rain and then the fine sand clogged and had to be removed by pick and shovel. At the mouth of the chute the gravel would not spread any flatter than 1½ to 1, although it left with considerable velocity. When a cone of earth formed up to the mouth a new chute higher or slightly to one side had to be constructed. Large stones and frozen cakes 3 ft. across passed down, but they tended to break the bottom plank by bouncing. The gravel wore the plank somewhat as horses' hoofs would have done. Probably two sets of 3-in. plank were used up. Altogether 30,000 cu. yds. were excavated at a cost of 30 cts. per cu. yd., including material and labor in building the chute, rigging the scraper and running the hoist. The work was done during February, March and April, with temperatures often far below zero and the hill face deeply frozen.

Material was loaded over the top of tunnel and also against the outside to correct the side pressure of the hill, as indicated by Fig. 5.

The removal of the lower bench was completed in May, but timber posts and braces were set up to support the roof during settlement until early in June. Although heavy rains occurred which penetrated through the whole hill of gravel, yet the final settlement was not troublesome, and all props were removed and trains passed through by the end of June.

GENERAL DISCUSSION OF THE WORK.—Timber-lined tunnels are much exposed to fire from locomotive sparks. In this one the 3-in. space between the timber sets (Fig. 7) would have allowed sparks to get into the mass of timber packing above the roof. The upper part of the arch was therefore lined with sheet-iron plates No. 20 gage, against which the sparks strike and then fall straight down. Also the whole interior and the spaces between timbers were thoroughly sprayed with Forsyth's fireproofing liquid, a force pump being used to apply it.

The form of timbering gave satisfaction. A double centered arch allows of keeping the segments at a steep inclination to act as pillars without undue cross-breaking strains. The length of cap is reduced to a minimum and the miter joints present a good bearing surface. The wall-plate binds the work longitudinally and ensures a vertical transmission of the weight to posts. When the settling forward occurred at the west end none of the posts moved out of plumb, although the roof sets leaned over a foot. Cross sills are preferable to longitudinal ones, however, because they can be 2 or 3 ft. long and thus give greater area on loose material against settlement. They are also more easily placed, as the longitudinal sills require a drift to be driven to set them in ahead of the posts. The long sills also twist and roll over under pressure, but the short ones placed touching side by side are a continuous foundation platform, resisting alike pressure downwards and "kicking in."

At the east end "gumbo" was passed through for about 20 ft. No lagging, therefore, was placed behind the posts so as to allow the material to escape as it swelled through the 3-in. spaces between timbers. At this part a few cross sills were placed across between the bottoms of the posts. They were framed to form an inverted arch of three members.

As the material was practically all gravel, no ballast was required. Eighty-pound rails were used, laid with tie plates and Bonzano splice bars.

The tunnel was built 19 ft. wide instead of the standard 16-ft. width to allow of lining with brick or concrete. It may be mentioned, however, that to concrete a timbered tunnel involves difficult questions of detail, as, for example, the support of the wall-plates while the concrete wall is settling. Again a considerable thickness is required for a 15-ft. high wall of concrete. Steel ribs are probably better suited to reinforce a wood-lined tunnel. If settlement takes place, extra sets of steel may be inserted, but masonry once cracked is difficult to re-establish.

A trough girder filled with concrete as laid it seems possible for wall-plates and upon this steel or wooden roof sets could be placed. Steel posts of the I-beam type are preferable to wood and could be placed on cast-concrete sills with twisted rods embedded in the concrete. Having a sure foundation and a side wall, that could be concreted at pleasure, and an imperishable wall-plate already in place the renewal of the roof is not such a difficult proposition. The side walls could also be built of concrete blocks laid dry and grouted when placed, thus doing away with steel posts.

The west end cribwork withstood a very heavy thrust in the autumn of 1901, and also during the spring of 1902. The original location of the lower track of the loop cut into the toe of the hill slope and injured its stability so that the hill face and the crib upon it tended to slip down. The excavation, however, lightened the load and, in depositing against the toe of slope, a buttress of earth was formed. The creek below was diverted and the track moved out to allow of this.

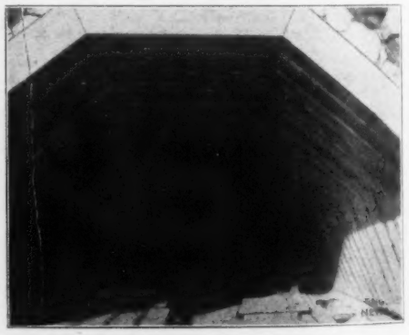

Fig. 8. View Showing Timber Lining of Tunnel.

The cribwork was of cedar throughout. Cross ties were placed 5 ft. apart and their ends were not cut to dove-tail joints, but they were laid upon the face and rear walls and drift bolted down with ¾-in. round bolts passing completely through the wall timbers. Between the tie ends filling pieces were spiked down to make a close face-wall and prevent the gravel from running out. The width of the crib was 20 ft. and down

the middle was a wall of longitudinals bolted to cross ties at all intersections. A system of timber props resting on a floor-sill grillage could have been reinforced and wedged up when side movement began and would have been easily replaced by concrete.

The work was done directly by the Canadian Pacific Ry. under Mr. P. A. Peterson, Chief Engineer. Mr. Olaf Olsen, a well-known tunnel man, managed the work and his care and experience were invaluable. There were no strikes, no injuries and no loss of life during nearly a year and a half.

IMPROVEMENTS AT THE TOPEKA SHOPS OF THE ATCHISON, TOPEKA & SANTA FE RY.

The main shops of the Atchison, Topeka & Santa Fe Ry. are located at Topeka, Kan., and these shops will do most of the heavy locomotive work for the entire system, which aggregates about 8,000 miles, with about 1,100 locomotives. There are somewhat extensive shops at Albuquerque, N. M., at Cleburne, Tex., and at San Bernardino, Cal. (the latter being new and operated by electric power throughout), but these serve principally for local and minor work. All such work as the building of new engines and rebuilding of old engines is done at the Topeka shops. The original shops are old and not well adapted to modern conditions or economical work, and are of insufficient capacity to meet present demands. Comprehensive plans have therefore been made for a complete reconstruction and rearrangement of the plant, to give greater facility, capacity and economy for the work. This reconstruction is being carried out gradually, but some of the large new shops are now practically completed.

The following article has been prepared from plans and information furnished by the engineering and mechanical departments, and from information gathered during a visit to the plant. The general plans were prepared under the direction of Mr. W. B. Storey, M. Am. Soc. C. E., Chief Engineer. The structural design of the shops was prepared by Mr. A. F. Robinson, M. Am. Soc. C. E., Bridge Engineer; Mr. George R. Henderson, M. Am. Soc. M. E., is Superintendent of Motive Power; Mr. Alfred Lovell, M. Am. Soc. M. E., Assistant Superintendent of Motive Power; Mr. Purcell, Superintendent of Shops, and Mr. F. H. Adams, Engineer of Shop Extension. The offices of the mechanical department for the entire A., T. & S. F. Ry. system, together with the drafting rooms and laboratory, are in a stone building at the west side of the works.

The present works turn out about 20 repaired and rebuilt locomotives monthly, and build 10 or 12 new locomotives each year. With the new shops in operation, it is expected that 25 or 30 new engines will be built every year, and that the monthly output will be about 40 locomotives built, rebuilt and repaired. At present the works employ about 2,000 men, but when the increased facilities are in full operation the number will be increased to about 2,500. It is expected that the new shops will be fully equipped and in operation by next May.

GENERAL PLAN.

The general plan of the works as they stand at present is shown in Fig. 1, the new buildings being indicated by hatched outlines. These new buildings are of brick and steel construction and comprise the following: 1, locomotive erecting, machine, boiler and tender shop, 852 × 154 ft.; 2, blacksmith shop, 400 × 100 ft.; 3, wheel shop, 180 × 56 ft.; 4, power house, 176 × 57 ft.; 5, three lavatory and locker buildings, 76 × 26 ft.; and 6, a three-story brick pattern shop (near the roundhouse), 40 × 75 ft.

The main line to Kansas City and the east runs along the south side of the works, and the line to Atchison runs directly through them. Between this line and the new shops are the car shops. These include a two-story woodworking shop, 86 × 300 ft.; freight car repair shop, 794 × 144 ft.; coach truck repair shop, 40 × 112 ft.; passenger car erecting shop, 90 × 320 ft., and passenger car paint shop, 90 × 320 ft. These two latter buildings are of stone, and each is served by a transfer table 63 ft. wide and 332 ft. long. The woodworking shop is of brick, and the other buildings are of wood. There is also a large dry kiln of brick construction and a duplicate of this is to be built shortly. Near the dry kiln is a drop-test hammer, and opposite it is the fire engine and main fire alarm station, also of brick. West of the line to Atchison are the old locomotive shops, the scrap yard, and the roundhouse, together with the various auxiliary facilities.

The old machine and boiler shop is a brick building, 770 × 75.5 ft., with an east wing, 125 × 300 ft., which forms part of the erecting shop. Behind the wing is a transfer table, 60.5 × 100 ft. This wing is to be utilized as a scrap working shop, forming part of the rearranged facilities for handling scrap. The various small buildings north of the wing will be cleared away and the space laid out for a systematic arrangement of scrap yard, with tracks and bins for economical and convenient work and storage. Old engines are broken up on tracks radiating from the turntable in the scrap yard. For cleaning tender tanks, a sand-jet machine is used, designed by Mr. Gibbons, foreman of the tender shop. This work is now done in the space between the roundhouse and turntable, but will later be done outside the north end of the new shop. A freshly cleaned tender looks as though it had been painted with aluminum paint. A machine of this kind is to be mounted on a car and used for cleaning bridges before repainting.

When the new locomotive shop is in full operation, all locomotive and tender work will be done in this one building. The main portion of the old machine shop will be utilized for what is known as the "water service" department, doing all machine, manufacturing and repair work for shop machinery, etc. The brass foundry (which it is intended to modernize at an early date) will also remain in the north end of this building, and an iron foundry may be established. At present all iron castings are made by John Seaton, of Atchison, Kan.; at a contract price of a certain sum per ton per year.

The roundhouse is a stone building 80 ft. wide, having been designed to give ample room for repair work at benches against the outer wall. The house is thus able to take in the largest modern engines, the tracks being lengthened and the working space correspondingly reduced. The ra-

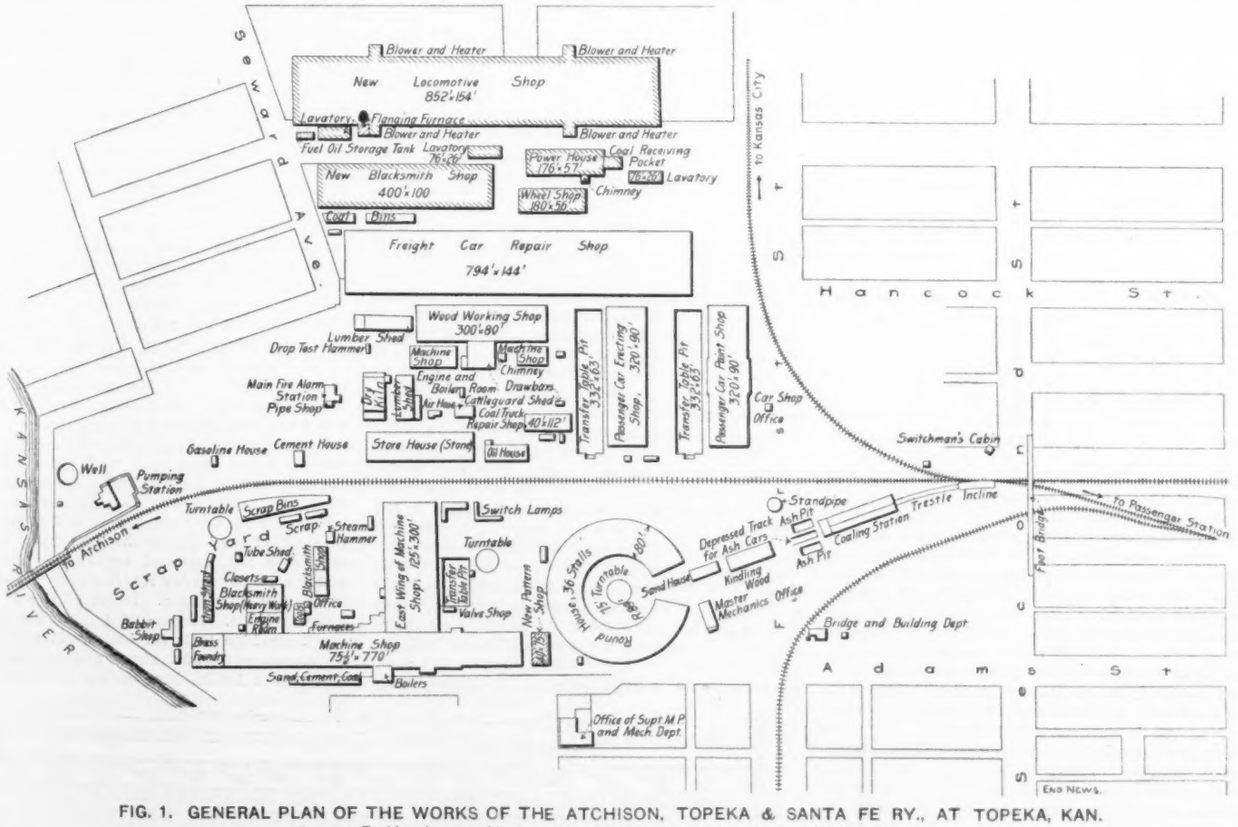

FIG. 1. GENERAL PLAN OF THE WORKS OF THE ATCHISON, TOPEKA & SANTA FE RY., AT TOPEKA, KAN.
George R. Henderson, M. Am. Soc. M. E., Superintendent of Motive Power.

dius of the inner wall is 89 ft. There are 36 stalls, the space for three of which is at present used as a tank or tender shop. The present turntable is operated by a small modified Brotherhood three-cylinder air engine, known as Tatlow's patent turntable motor. This is supplied with air by coupling it to the brake hose at the pilot or tender of the engine on the table. A new 75-ft. turntable is being built at the Chicago works of the American Bridge Co., and this will be operated by electricity. The two car shop transfer tables are also to be operated by electricity. The pneumatic turntable motor will be transferred to some point where electric power is not available.

The coaling station has a double row of bins, with ten bins and chutes on each side, and the coal cars are hauled up the incline to the bins by a gasoline engine. This engine is to be replaced by an electric motor. There are two ashpits, one in each coaling track, with a depressed track between for the ash cars. The pits are shallow, with the rails elevated above the normal surface of the yard, and supported on cast-iron pedestals. The other facilities provided include a stand-pipe with spout for supplying the engines with water, a platform for stacking kindling wood, and a sand house with dryer, conveyor and spout for feeding sand into the engine sand boxes by air pressure.

For handling work in the yard, there is a four-wheel oil-burning tank engine (with side tanks), having a 4-ton pneumatic jib crane mounted on the smokebox, the smokestack passing up through the turntable of the crane. This machine is also very useful in clearing yard wrecks.

NEW LOCOMOTIVE SHOP: CONSTRUCTION.

This building is intended for all the locomotive work, including boilers and tenders. It is of particular note for its great size and the peculiar features of its design. In general plan it is 852 ft. long and 153 ft. 10 ins. wide, the width being divided into a center span of 74 ft. 3 ins. and two side spans of 39 ft. 9 ins. It is of self-supporting steel frame construction, with concrete foundations and floor, 13-in. brick walls, and Ludowici tile roof. There is no sheathing under the tiles, which thus constitute the sole covering.

The most striking feature of the design is that the saw-tooth or weaving-shed type of roof is adopted for the side spans, the glazed vertical sides of the ridges facing northward. This feature was introduced with the view of making the shop as light as possible. The arrangement could not well be used where heavy snows are frequently experienced, as the snow would pack between the ridges, but there are comparatively few heavy snow storms in the vicinity of Topeka. In addition to this arrangement, the greater proportion of the area of the side walls is composed of windows, while the exposed parts of the sides of the central span (between the ridges of the side spans) are also glazed. There are also several windows in the end walls. The roof of the central span has on each side of the ridge a skylight 12 ft. wide, extending the full length of the building. These skylights are fitted with translucent fiber instead of glass. By these various means an exceptionally good lighting effect and diffusion of light are obtained, and the shop is in fact remarkably light even on a gloomy winter day.

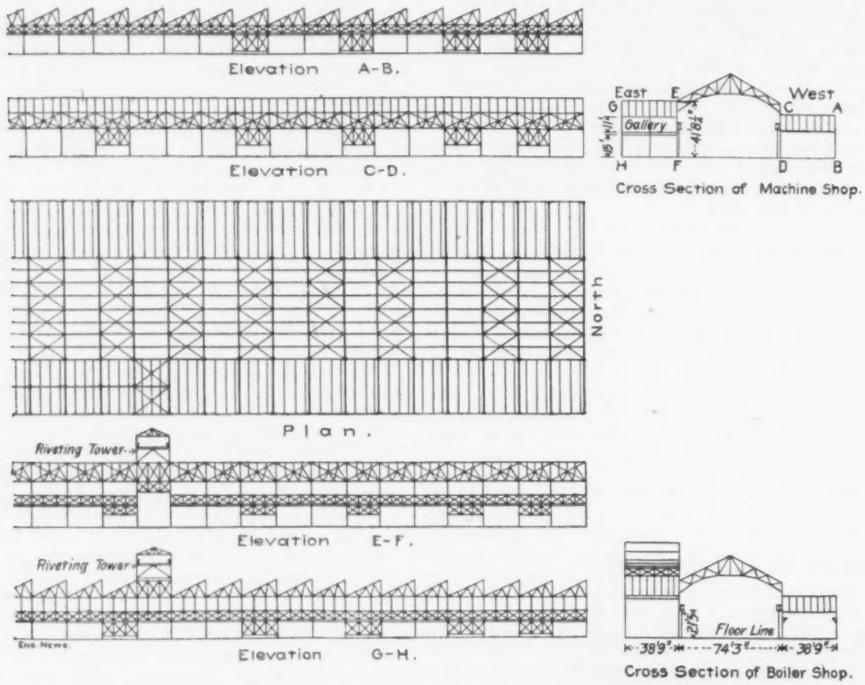

FIG. 2. PART ELEVATIONS AND PLANS OF STEEL STRUCTURAL WORK OF NEW LOCOMOTIVE SHOPS.
A. F. Robinson, M. Am. Soc. C. E., Designer.

The columns are built up of pairs of 15-in. channels, and independent columns of similar construction carry the double-web box girder runways for the electric traveling cranes which run the entire length of the central span. Fig. 2 shows the elevations, sections and plans of the steel structural framework, and Fig. 3 is a partial elevation on the east side. Fig. 4 shows the design of the central roof trusses and the lattice girders which form longitudinal bracing between the trusses. This longitudinal bracing is not continuous but is fitted only between alternate pairs of trusses. End trusses are built into the walls, as these walls are pierced by numerous windows and doors and are not relied upon in any way to support the roof. Portal bracing is fitted between the side or wall columns at intervals. No metal less than ⅜-in. thick is used in the structural work.

The roof trusses are proportioned for a load of 15 lbs. per sq. ft. for the roofing, 10 lbs. per sq. ft. for snow, and 25 lbs. per sq. ft. for wind pressure, or 50 lbs. per sq. ft. in all. Provision for expansion and contraction is made at intervals of 100 ft. The structural work for this shop was built at the Toledo Works of the American Bridge Co. The steel is painted a light grey and the brick is whitewashed, a pneumatic machine being used for the latter work.

The arrangements for lighting the shop by day have already been referred to. For night work there will be arc lights for general lighting and incandescent lamps convenient to the tools, etc. There is no monitor roof, but ventilation is provided for by Star ventilators 25 ft. apart along the ridge of the main roof. The building is heated by the Sturtevant hot blast system. On each side are two fan rooms, each containing a steam-driven blower fan and a heating chamber filled with coils of pipe through which passes the exhaust steam. The hot air is delivered into two longitudinal underground conduits parallel with the lines of columns, with a duct leading to the surface at each column. Each duct is fitted with a vertical sheet iron pipe 7 ft. high, with a flaring head to deliver the air horizontally. The plant is guaranteed to maintain a temperature of 70° F. throughout the shop in zero weather.

The building has a concrete floor over its entire area. The concrete is 6 ins. thick and is composed of 1 part Louisville cement, 2 parts sand and 4 parts stone. On the concrete are laid pine nailing strips, 1¾ × 4 ins., 18 ins. c. to c., to which is spiked the 1¾-in. splined hard-maple flooring. All tracks in the shop are laid with 75-lb. rails on ties of New Mexico pine treated by the zinc-chloride process, the floor concrete being laid only to the ends of the ties, so that adjustment of the track can be made without tearing up the floor. At the engine pits (which are of concrete) the rails are laid on longitudinal timbers. The concrete for column foundations is composed of 1 part Iola Portland cement, 3 parts sand and 5 parts stone. These foundations are 8 to 15 ft. deep, extending to solid clay. They are built up with gas pipe sleeves to form holes for the anchor bolts, and the holes in the bed plates of the columns are slotted longitudinally so as to allow of adjustmnt for any slight variation. The foundations for the tools, etc., are also of the Portland cement concrete, and these are built by the mechanical department to suit its own requirements as to arrangement of tools. This arrangement was only arrived at after careful study, and of course no changes can be made without expensive work in cutting out and replacing concrete. One suggestion for the floor construction was to use a brick floor with no concrete, so as to allow for future changes and putting in new foundations.

NEW LOCOMOTIVE SHOP: EQUIPMENT.

On the west side, the first 450 ft. from the south end will be for the machine shop tools for heavy work, with the wheel presses and lathes at the south end, followed by the cylinder work, and the frame work. Further north, on the same side, are the boiler shop tools, with plate rolls, flanging presses and flanging furnace, punches, shears, etc. The north end of this side of the building will be for the tank machinery and work. On the east side of the building the tube rattler will be at the north end, followed by the tube department and tracks for tender repair work. These extend to the riveting tower. South of this is the tool delivery room. Beyond this again are groups of small machine tools for bolt work, and for work on crossheads, rods, shoes and wedges, pistons and piston heads, etc., ending with driving box work at the south end. On this side of the shop is a gallery 525 ft. long. Beginning at the south end this is laid off for the brass work, stud and screw-making for stock, air brake repair work, the manufacturing department of the tool room (served by a dumb-waiter service from the tool delivery room below), and the tin shop. The remaining portion of the gallery forms what is termed the coffee room, 40 × 75 ft.; this will be

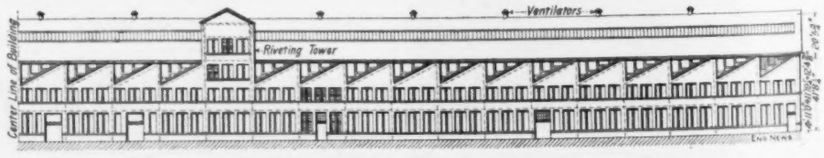

FIG. 3. HALF EAST ELEVATION OF NEW LOCOMOTIVE SHOP; A., T. & S. F. RY.
(Showing Riveting Tower and Weaving Shed Roof.)

fitted with chairs, tables, a piano, etc., and here the men can eat their lunch and hold meetings or entertainments. The gallery will be served by two wide stairways and two elevators, operated by 7½-HP. motors, and there will be a small elevator or dumb-waiter between the upper and lower floors of the tool room.

The south end of the central bay will be used for dismantling and erecting locomotives. This has three longitudinal tracks 23 ft. c. to c., 450 ft. long. The middle one has a pit 450 ft. long, and each of the others has a pit 160 ft. long. An engine to be repaired will enter on the middle track, and there be stripped, the parts removed being placed on racks or taken to the lye tanks to be cleaned, or to the tools for repairs, as required. The engine will then be picked up bodily by the cranes and set on trucks or blocking at any desired location in the machine or boiler shop. The pits of the side tracks will be used for placing the engine on its wheels again, setting the valves, etc. With this arrangement for moving the engines, no drop pits are required, which are generally a troublesome but necessary feature.

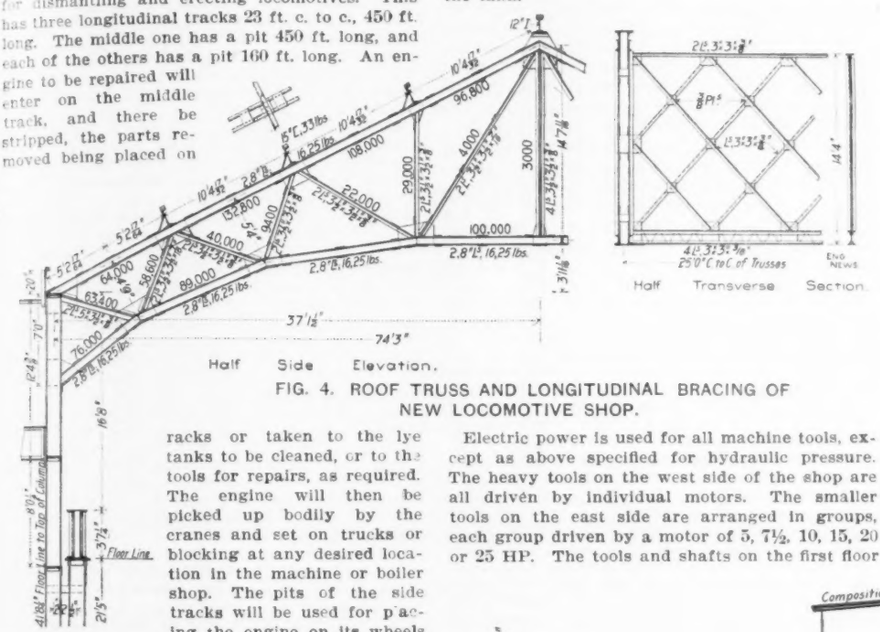

FIG. 4. ROOF TRUSS AND LONGITUDINAL BRACING OF NEW LOCOMOTIVE SHOP.

Two 60-ton Whiting electric overhead traveling cranes serve the entire length of the central span of the shop. Each crane runs on eight wheels (four at each end), has four motors, and is fitted with a 5-ton auxiliary hoist for light work. The main hoisting block has six sheaves. In the west span, over the heavy tools, are two 5-ton three-motor electric traveling cranes to serve the entire length of the shop. Outside the southwest corner is a 5-ton pneumatic jib crane for handling wheels. In the open space south of the east span of the shop will be the lye tanks for pickling and cleaning old and dirty work, while outside the north end will be tracks on which tenders can be cleaned by the sand jet.

Near the middle of the east side of the shop is the riveting tower, 62 ft. high to the rails of the cranes which serve the two hydraulic riveters. One of the riveters has a 17-ft. gap, arranged for six pressures up to a maximum of 150 tons on the rivet; this can drive 1½-in. rivets. The other has a 12-ft. gap and three pressures up to a maximum of 100 tons on the rivet. The work at these two machines is handled by two Bement & Miles hydraulic cranes of 25 and 10 tons capacity, respectively. The flanging machinery on the west side includes a 450-ton hydraulic flanging press, served by a 12-ft. oil-burning furnace. There is also a pair of pneumatic flanging clamps for hand flanging. Work flanged by hand is annealed in the flanging furnace, which is in a room beside one of the fan rooms, and is thus clear of the shop floor. All hydraulic apparatus operates under 1,500 lbs. accumulator pressure. The tube rattler is of special design and consists of two endless sprocket chains dipping into a tank of water and driven by an electric motor. The boiler tubes are slung in these chains and agitated by their revolution; when the work is finished the chains are wound up, lifting the bundle of tubes out of the tank.

Electric power is used for all machine tools, except as above specified for hydraulic pressure. The heavy tools on the west side of the shop are all driven by individual motors. The smaller tools on the east side are arranged in groups, each group driven by a motor of 5, 7½, 10, 15, 20 or 25 HP. The tools and shafts on the first floor are arranged transversely of the shop so as to leave passageways for ready access to the main floor. On the gallery, the main line shaft runs lengthwise of the building. The hangers for shafts are clamped instead of bolted to the gallery beams, etc., so that there is no cutting or drilling of the structural iron and the hangers can readily be shifted if necessary. Hydraulic power at 1,500 lbs. pressure is distributed through the shop for riveting, flanging, etc. Compressed air is distributed at 100 lbs. pressure. Most of the electrical equipment is of the General Electric Co.'s make.

For locating the positions of the tools, after a general arrangement of the departments of work had been decided upon, a large plan (to a scale of 4 ft. to the inch) was prepared and laid out on a table. Plans of the individual machines were then drawn on separate sheets to the same scale, and were cut out and used as templates. These were arranged and pinned in position, so that any interference or undesirable situation could be detected at once, and the templates shifted until a satisfactory arrangement was arrived at. The locations were then plotted on the plan, and drawings got out for the foundation work.

BLACKSMITH SHOP.

This shop is 400 × 100 ft., of similar construction to the locomotive shop. The ends, however, are of corrugated iron above the level of the side walls; while the roof has a tile covering on the side slope and a gravel composition on the flatter central portion. To provide good ventilation there is a monitor roof about 25 ft. wide and 6 ft. high, fitted with windows in alternate panels. Fig. 5 shows the general design of the building. The columns are pairs of 15-in. channels, supporting steel roof trusses of 100 ft. span, placed 25 ft. apart and arranged to support the shafting. This shop has a cinder floor. The structural work was built at the Lassig (Chicago) works of the American Bridge Co.

At the north end are the heavier steam hammers, of which there will be 14 in all, ranging from 5,000 lbs. to 250 lbs. capacity. These are scattered throughout the shop. There is no traveling crane, but the work is handled at the anvils by a post crane at each hammer. These cranes have overhead horizontal booms on which run trolleys. There are five heating furnaces, arranged for burning oil normally, but capable of being quickly converted for using coal. Three of these have boilers over them. All other furnaces in the shop burn oil fuel. The oil is the Beaumont, Tex., oil, delivered in large tank cars, from which it flows by gravity through a 6-in. pipe into an underground tank of 20,000 gallons capacity. This tank is lined with brick and has a fireproof roof. Its position is shown on the plan, Fig. 1. Two pressure tanks of about 10 barrels capacity each supply oil to the burners under 20 lbs. air pressure, the pipes being laid at such a grade that when the air pressure is shut off the oil will drain back to the pressure tank.

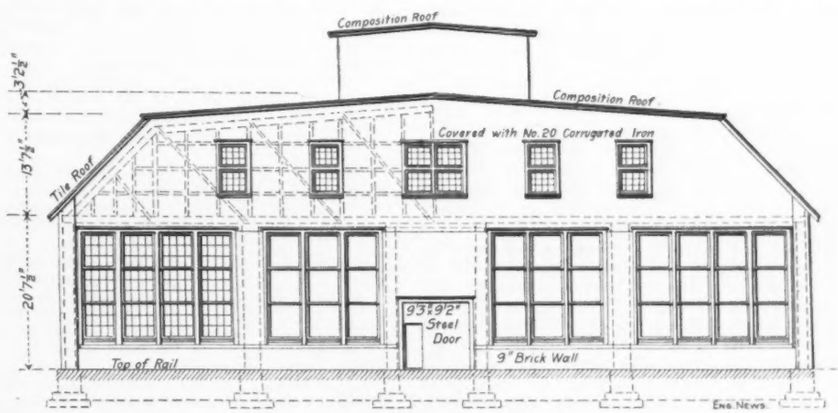

FIG. 5. END ELEVATION OF NEW BLACKSMITH SHOP.

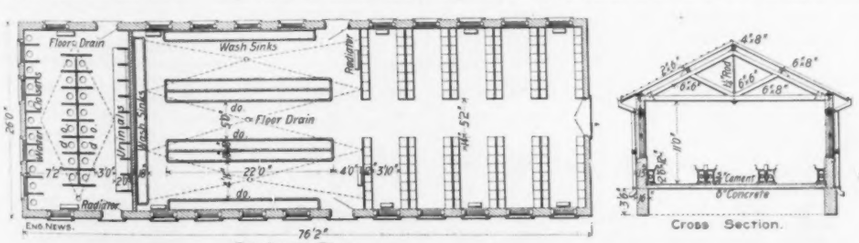

FIG. 6. PLAN AND CROSS-SECTION OF LAVATORY BUILDING; A., T. & S. F. RY. SHOPS.

Four Sturtevant pressure blowers supply the blast for all purposes, including about 40 open forge fires, which are not provided with hoods or chimneys. The fans are all motor-driven, and include one No. 7, two No. 8, and one No. 9, the latter direct-connected to the countershaft. At the south end of the shop is the spring department, with shears for cutting the plates to length, a punch for nibbing the plate, tapering rolls, hanger slot punches, plate and band-heating furnaces, three tempering furnaces, hydraulic spring squeezer and banding press, and a spring testing machine.

WHEEL SHOP.

This building is also of steel structural construction, 56 × 180 ft., with brick walls and tile roof. It is intended for the preparation of car wheels and axles, bolt and nut work, and general iron work for the car department. The principal ma-

chinery equipment is noted below. Individual motors are used to drive the wheel presses and double punch and shear, while the other machines are arranged in groups of about 20 HP., each group driven by a motor. In addition to the tools mentioned below there are emery wheels, an oil separator, etc.

1 Stripping and 1 mounting wheel press.
2 Car wheel borers.
6 Double car wheel lathes.
4 Double car axle lathes.
2 Double axle cutting-off and centering machines.
20 Nut tapping spindles.
14 Bolt cutting heads.
3 Six-spindle arch bar-drills.
1 Six-spindle truck end drill.
7 Upright drills.
1 Engine lathe.
1 Shaping machine.
1 Double punch and shear and 1 pneumatic portable riveter; these two machines are for work on truck channels and the steel platforms of passenger cars.

POWER HOUSE.

The new power plant at present supplies electric, hydraulic and pneumatic power for the new shops only, as well as electric light for the old and new shops; eventually it will also supply power for the entire plant. In the engine room are three Ball horizontal tandem-compound engines of 325 HP. each, directly connected to a General Electric direct-current, 250-volt, 200-KW. generator. Space is provided for a fourth unit of this size. There is also a 120-HP. engine directly connected to a 75-KW. generator. There are two air compressors; one is a Rand machine with two steam cylinders 20 × 48 ins., and air cylinders 16 × 48 and 28 × 48 ins.; the other is an old Corliss engine with Ingersoll-Sergeant air cylinders, 18¼ × 48 ins., attached tandem. In this room is a 7-ton hand crane for handling the machinery in repairing the engines, etc. The hydraulic power is generated by Worthington pumps of the simple duplex type, with cylinders 18½ × 10 ins. and 4½ × 10 ins. The boiler room contains six locomotive type boilers, built at the shops, and rated at 200 HP. each. Space is provided for two additional boilers. These are fitted with the Green Engineering Co.'s chain grates (5 ft. 2 ins. × 9 ft.) under the fireboxes, and the flues lead to a brick chimney 160 ft. high, 7 ft. 6 ins. diameter inside. This was built by the Alphons Custodis Chimney Construction Co., of New York.

The coal brought in on railway cars is dumped into a steel pocket in a concrete pit below the level of the ground, outside the south end of the building. The sides and bottom of this bin slope to the center, where the coal is delivered into an endless bucket conveyor built by the Link Belt Machinery Co., of Chicago. This carries the coal up and over outside elevated ash bins, through the south wall of the power house and over elevated coal hoppers of 300 tons storage capacity. The conveyor then passes down the north wall of the boiler room, and returns through a tunnel, running past the doors of the ash pits under the boilers. Spouts conduct the coal from the overhead storage lines to the hoppers of the chain grates. The ashes can be dumped from the ash-pits into the conveyor, which carries them out and elevates them to the level of the overhead ash-bins outside, into which they are dumped. Empty coal cars can be loaded with ashes by spouts from these bins.

As the water contains an objectionable proportion of lime, it is to be treated by the Tweedale water-softening process.

LAVATORIES.

To provide clothes lockers, closets and toilet accommodations for about 960 men employed in the locomotive and blacksmith shops, there are three lavatory buildings 76 × 26 ft. These are single-story brick buildings with wooden roof trusses and tile roofs, as shown in Fig. 6. One end of the building forms a locker room with wooden lockers (having expanded metal doors) for 320 men. Adjacent to this is the wash room, with seven sinks, the length of the sinks being 140 ft., with 70 individual water cocks. At the opposite end of the building are the closets and urinals, but this room is entirely shut off from the rest of the building, as shown. It contains 27 self-flushing closets and 9 wall urinals, with floor drain.

PURIFYING WATER FOR LOCOMOTIVE BOILERS ON THE CHICAGO & NORTHWESTERN RY.*

By G. M. Davidson.†

In the northern part of Wisconsin and Michigan, along the Ashland and Peninsula Divisions, the country is dotted with small lakes and swamps which act as reservoirs for the storage of water derived from melted snow and rain. This water does not get a chance to percolate through the soil, but runs quickly into the swamps, lakes and streams. There is no trouble with locomotive boilers accumulating scale when running through that region. Practically only natural soft water is used.

Along the shore of Lake Michigan and in southern Wisconsin, where water can be conveniently pumped from the lakes and rivers, the water is comparatively soft and is considered good for boiler purposes.

On the Iowa division some of the waters contain considerable scale-forming material. They are hard waters and on account of the fast time of the passenger trains, heavy tonnage of freight trains, and large number of locomotives in service on this division, are the cause of much expense to the company, as well as much annoyance and trouble to the motive power department.

On the Minnesota and Dakota Division the waters are much worse than elsewhere on this railroad. Not only do they contain in solution much lime and other scale-forming matter, but many of them also contain a very large quantity of alkali.

Analyses of typical waters of each of these four localities are given in the table below:

PRACTICAL RESULTS FROM THE USE OF SOFT AND HARD WATER IN CHICAGO & NORTH-WESTERN RY. CO.'S LOCOMOTIVE BOILERS.

The principal business of that portion of "The North-Western Lines," located in northern Wisconsin and northern Michigan, is transporting iron ore from the mines to the lake ports of Escanaba and Ashland. This business is practically a summer business, for as soon as winter sets in and navigation on the lakes closes, the heavy business ceases until spring, when navigation reopens. As soon as the transportation of ore is stopped in the fall, the large locomotives engaged in that traffic are transferred to other divisions and are used for hauling the fall crops to market. While these locomotives are engaged in the ore traffic in the region where the water is good they give little or no trouble from leaky flues, cracked plates or other troubles attributed to bad water. As soon, however, as they are transferred from the good water district into the poor water district where the water is known to contain much lime, magnesia and such scale-forming matter, they commence to give trouble.

*Abstract of a paper read before the Western Railway Club at Chicago on Feb. 17.

†Chemist and Engineer of Tests, Chicago & Northwestern Ry., Chicago.

BOILER COMPOUNDS.

The number of boiler compounds on the market are so numerous that I will only refer to a few of them in a general way. Some are entirely mechanical in their action, such as wires, plates, twigs and brushes, which are supposed to catch and entangle the scale-forming matter and prevent it depositing and forming hard scale. Others are supposed to have a chemical action, and indeed are well known chemicals that do have such action, but the high prices of such chemicals limit their use. Others, like potatoes, peas, wheat, moss, crude oil, kerosene, etc., are of some little benefit because they form centers about which the lime and magnesia gather and thus prevent the formation of hard scale.

It was once customary for owners of boilers to use various boiler compounds, boiler purgers, boiler scale dissolvers, and similar nostrums, which were offered from time to time, and which were represented to cure the evils due to the use of poor water. After trying a great many boiler compounds it was concluded that while many of them seemed to give fairly good results, yet a large portion were humbugs. Many of them contained well-known chemicals which, when properly used, would give fair results. Some contained material that yielded doubtful results. Some were found to contain chemicals which were known to be very harmful to boilers. A few of them which were manufactured in the vicinity of Chicago were found to consist largely of Lake Michigan water, which was disguised by mixing it with certain material to change its appearance. Nearly all of the boiler compounds that gave fairly good results were found to contain soda ash. Generally this was colored or disguised in such a manner that a chemical analysis was necessary to detect it.

Some ten years ago it was found that if properly used, soda ash in locomotive boilers would yield fairly good results. You will note that I say "if properly used," because it was found that if used improperly, soda ash would do more harm than good to a locomotive boiler. When soda ash was first used some engineemen declared it did good work in locomotive boilers, while others declared just the reverse. Upon investigation it was found that the proper use of the blow-off cock had much to do with the results obtained. If the engineman used the blow-off cock frequently and thus removed the "sludge" and concentrated water from his boiler the results were generally fairly satisfactory. A boiler, however, was not designed for the purpose of treating water with chemicals, and the use of a locomotive boiler as a vessel in which to carry on a chemical operation was found to be poor practice. As the use of boiler compounds required their introduction into the boiler, they did not meet with very much favor.

Briefly stated, the scale in locomotive boilers is due to one or more of the following causes:

1. Deposition of lime and magnesia carbonates, due to the boiling off of the carbonic acid gas from the water in which they were dissolved.
2. Deposition of sulphate of lime, due to high temperature in the boiler.
3. Deposition of magnesia compounds, due to their decomposition in the boiler.
4. Deposition of sand, clay and other matter that was suspended in the water.
5. Deposition of alkali salts, due to concentration.

The table on the opposite page presents in condensed form some well-known facts in regard to troubles with boiler waters:

It will be noted that slaked lime and soda ash in the above table are frequently prescribed as remedies. There are many other chemicals that can be used to accomplish the same purpose, but they are much more expensive and generally no more effective than the two designated.

ANALYSES OF WATERS USED IN LOCOMOTIVE BOILERS; CHICAGO & NORTH-WESTERN RY.
(Figures show weight in Troy grains in 1 U. S. gallon (231 cu. ins.)

Stations	Waters of Wisconsin. Grand Rapids.	Waters of Wisconsin. Cedar.	Waters of Michigan. Wellington.	Waters of Michigan. Little Lake.	Waters of Illinois. Chicago.	Waters of Illinois. Cary.	Waters of Wisconsin. Oshkosh.	Waters of Wisconsin. Red Granite Junc.	Waters of Iowa. Council Bluffs.	Waters of Iowa. Dunlap.	Waters of Iowa. Dennison.	Waters of Iowa. Boone.	Waters of Minnesota. Tyler.	Waters of Minnesota. Walnut Grove.	Waters of South Dakota. Redfield.	Waters of South Dakota. Salem.
Source of supply	Well or bok Wisconsin River.	Spring.	Branch of Presque Isle River.	Well, 350 ft. from lake.	Lake Michigan.	Fox River.	Lake Winnebago.	Creek.	Wells, 70 ft. deep.	Well, 28 ft. deep.	Well, 25 ft. deep.	Well 104 ft. deep.	Well, 575 ft. deep.	Well, 40 ft. deep.	Well, 18 ft. deep.	Well, 16 ft. deep.
Total solids*	5.24	1.89	5.49	4.96	7.78	14.23	11.24	10.85	53.67	40.42	24.19	23.04	140.36	201 16	233.50	152 88
Carbonate of lime	1.15	0.39	1.51	0.06	4.46	6.02	4.67	5.11	24.39	16.11	14.68	13.46	35.08	42 75	46.68	13.78
Carbonate of magnesia	1.14	trace.	0.55	trace.	2.20	5.64	3.32	3.80	1.18	2.25	2.51	7.06	8.20	19 01	2.75	4.93
Sulphate of lime	0.78	....	0.23	1.90	0.30	0.07	0.43	....	6.22	5.41	3 60	.. ..	15 04	42.59	8.70	84.45
Sulphate of magnesia	....	....	....	0.59	....	....	0.77	....	13.33	9.92	1.20	...	24.75	32 10	56.35	37.70
Iron and alumina oxides	0.03	0.08	0.00	0.29	0.02	0.12	0.09	trace.	0.34	0.16	0.09	trace.	0.30	trace.	1.39	0.03
Silica	0.93	0.00	0.50	0.51	0.30	0.48	0.23	0.67	1.42	1.52	0.96	1.74	2.00	1.45	2.11	1.57
Incrusting solids	4.03	1.07	2.88	3.35	7.28	12.33	9.51	9.58	46.88	35.37	23.04	22.26	85.37	137 90	117.98	142.46
Alkali chlorides	0.04	0.25	0.48	1.30	0.22	0.57	0.62	0.27	1.21	2.06	1.15	0.69	1.46	1.21	13.50	9.77
Alkali sulphates	0.56	....	....	0.11	0.28	1.33	1.11	1.00	5.58	2.99	....	trace.	53.53	62.05	102.02	0.65
Organic matter	0.61	0.57	2.13	0.20	....	....	....	....	....	....	....	0.69†	....	....	....	....
Non-incrusting solids	1.21	0.82	2.61	1.61	0.50	1.90	1.73	1.27	6.79	5.05	1.15	0.78	54.99	63.26	115 98	10.42
Scale-forming matter in 1,000 gallons, lbs.	0.57	0.15	0.41	0.48	1.04	1.76	1.36	1.37	6.69	5.05	3.29	3.18	12.19	19.70	16.85	20.35

*Dissolved in 1 gallon. †Alkali carbonates.

A Handy Diagnosis of Boiler Feed-Water Complaints.

Cause of trouble.	Nature of trouble.	Remedy.
Carbonate of lime.	Soft scale.	Treatment with slaked lime.
Carbonate of magnesia.	Soft scale.	" " slaked lime.
Sulphate of lime.	Hard scale.	" " soda ash.
Sulphate of magnesia.	Hard scale.	" " slaked lime and soda ash.
Carbonate of iron.	Soft scale.	" " slaked lime.
Chloride of magnesia.	Corrosion.	" " soda ash.
Sediment, sand, clay, mud, etc.	Scale.	" " alum. Filter. Allow to settle.
Dissolved oxygen and carbonic acid gas.	Corrosion.	" " slaked lime.
Organic matter.	Foaming and corrosion.	" " chemicals.
Alkali.	Foaming.	Frequent blowing off.
Acid.	Corrosion.	Treatment with slaked lime.

We have seen by the foregoing that in order to remove from hard water the scale-forming compounds of lime and magnesia, it is only necessary to mix with the hard water the proper amount of slaked lime and soda ash. The mechanical operations required may be classified as follows.

1. Weighing, mixing and dissolving the lime and soda ash in water so that the resulting mixture will have a uniform and constant strength.

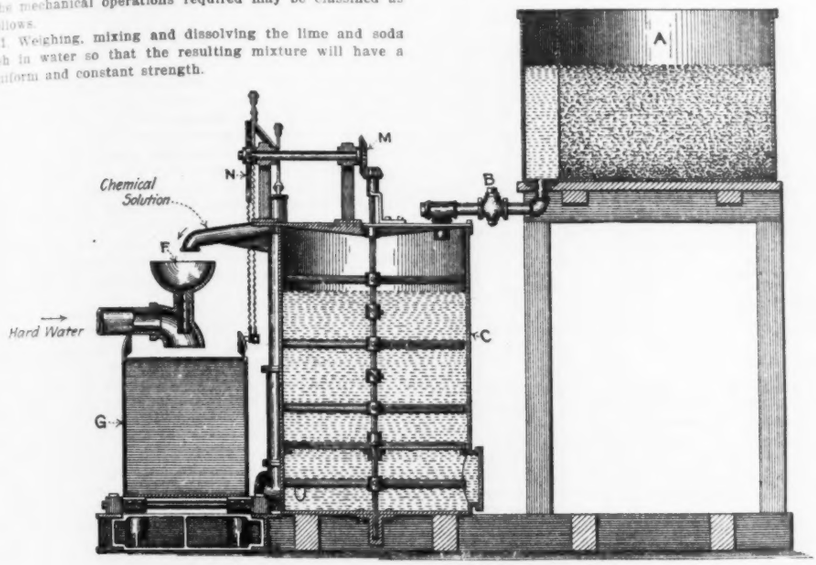

FIG. 1. SECTIONAL ELEVATION OF APPARATUS FOR PURIFYING FEED-WATER FOR LOCOMOTIVES; CHICAGO & NORTHWESTERN RY.

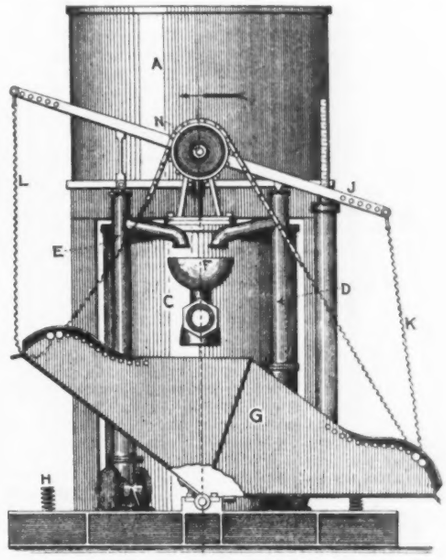

Fig. 2. Vertical Section at Right Angles to Fig. 1, Showing Tilting Tank.

2. Mixing a certain predetermined quantity of this chemical solution with a certain predetermined quantity of the hard water, and agitating the resulting mixture so thoroughly that the lime and magnesia compounds that were dissolved in the hard water are quickly thrown out of solution in the form of a white precipitate.

3. Separating and collecting this precipitate from the clear softened water.

These mechanical operations should be conducted at a minimum cost, and, therefore, the mechanical apparatus should be simple and as nearly automatic as possible; easily adjusted to suit the different waters; not liable to get out of order; be operated without any extra power other than an ordinary pump, such as is used at water stations; so simple that an ordinary pumper can attend to it without neglecting his regular work, and so cheap that the cost of installation does not prohibit its use.

The accompanying drawings illustrate the water purifying apparatus constructed and used by the Chicago & North-Western Ry. Fig. 1 is a section showing the arrangement of the different parts, Fig. 2 is an end elevation, Fig. 3 is a sectional elevation of the settling tanks and pump house, showing the location of the entire apparatus for storing, feeding, mixing and settling the water.

The primary object of this apparatus is to provide a suitable means for automatically measuring and mixing a predetermined quantity of a standard solution of chemicals with a predetermined quantity of hard water, so that the compounds of lime, magnesia and other scale-forming matter that are dissolved in the hard water may be thrown out of solution by the action of the chemicals. The secondary object is to provide means for separating the suspended scale-forming matter after it is thrown out of solution and delivering clear soft water to the storage tank from which locomotives are supplied.

The proper quantity of chemicals, usually lime and soda ash, having been determined, they are weighed out and dumped into the mixing vat A, where they are mixed and dissolved in a proper quantity of water to make the solution the strength desired. By opening the valve B this solution is allowed to run into the chemical tank C. To thoroughly mix and keep the solution stirred up in the chemical tank C stirring blades are fixed on the vertical shaft in the center of this tank. In order to measure and deliver predetermined quantities of the chemical solution the chemical tank C is provided with two pumps, D and E (Fig. 2), connected at the lower portions to the tank. The upper portions of these pumps have spouts which discharge into a funnel F attached to an elbow terminating on the hard water supply pipe, so that just before the hard water passes out of this pipe the chemical solution is mixed with it.

To obtain the best results it is essential that the quantity of the standard chemical solution and hard water be mixed in proper proportions and also that this be done regularly whenever the apparatus is being used, also that it be done economically. To do this a tilting vessel G is used. It is supported on a shaft located directly under the elbow from which the mixed hard water and chemical solution is discharged.

This tilting and measuring vessel is divided into two compartments of equal capacity. When it is in the position shown in Fig. 2 the mixture of hard water and chemicals falls from the discharge elbow into the left-hand compartment. When this compartment is nearly filled it counterbalances the weight of the other compartment, so that the vessel tilts until it strikes the spring H, emptying the contents of one compartment and at the same time bringing the other compartment under the discharge elbow. When this in turn is filled it reverses the movement of the tilting vessel. For convenience these compartments are made such size that 100 gallons of water are required to fill them to the point where they commence to tilt and empty their contents.

Having determined the amount of a standard solution of chemicals required to precipitate the scale-forming compounds from say 100 gallons of any hard water, it is necessary to mix it with the 100 gallons of hard water in one of the compartments of G. This is done by regulating the length of the stroke of the pumps which pump the standard chemical solution from the tank into the funnel F. These pumps, D and E, are operated by the tilting vessel.

The pump plungers are connected to a walking beam J, the ends of which are connected to the tilting vessel by the chains K and L. When the vessel is tilted to the left the plunger of the pump D is raised so that a quantity of the standard chemical solution is delivered into the funnel and flows with the hard water into the right-hand compartment. When 100 gallons are in, the vessel operates in the opposite direction, causing the other pump to deliver a quantity of the standard chemical solution into the funnel, from whence it flows with the hard water into the other compartment. It will be understood that the hard water is running constantly through the elbow and that the two pumps are intermittent in their action. The quantity of the solution delivered at each stroke is regulated by adjusting the length of the chains, so that a predetermined quantity will be delivered at each stroke.

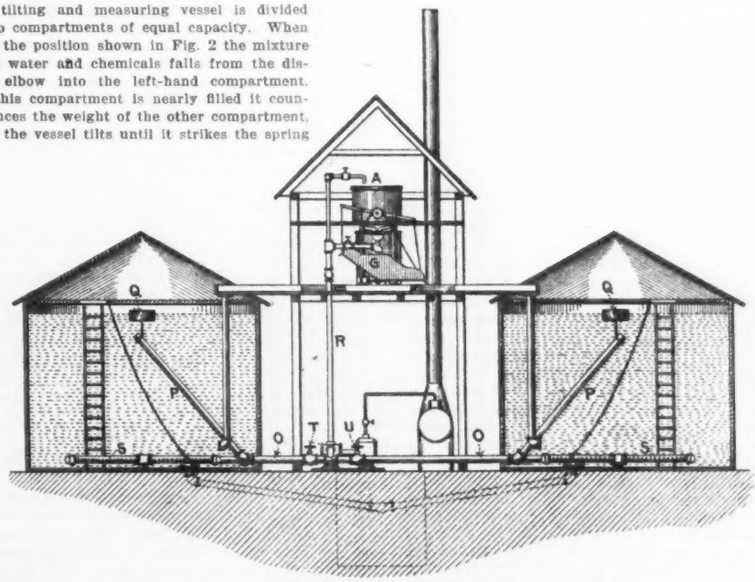

FIG. 3. GENERAL SECTIONAL ELEVATION OF WATER STATION WITH PURIFYING APPARATUS.

It is desirable to automatically and economically operate the vertical shaft in the chemical tank, so that the horizontal blades attached to it will keep the chemical mixture thoroughly agitated. To do this it is geared to the hori-

zontal shaft of the walking beam by the bevel gear M. The other end of the shaft is provided with a sprocket wheel N, around which a link belt chain passes, the ends of this chain bein gattached to the ends of the tilting vessel. It will readily be seen by this arrangement that whenever the tilting vessel moves, the stirring blades attached to the vertical shaft in the chemical tanks also move, thus agitating the mixture. For convenience in measuring the height of liquid in the tank a pipe is attached to the side of tank, near its bottom. In this pipe is a float atached to a graduated scale.

By referring to Fig. 3 it will be seen that the apparatus is located in the second story of the pump house and that the pump house is located between two tanks placed on the ground. The tilting vessel above described empties its contents into a wooden box, which is provided with troughs leading to the two settling tanks. These troughs are provided with shut-off gates so that the water can be run into whichever tank is desired. The troughs empty their contents into vertical pipes that extend to the bottom of the tanks and terminate in elbows. The object of this arrangement is to stir up the old precipitate that remains in the tanks from former treatments, in order to hasten the settling of the new precipitate. It is a well-known fact that if the old precipitate is stirred up well, the new light particles become attached to the old heavier particles and settle quickly.

After these tanks are filled or partially filled with the treated water holding the new precipitate in suspension, it is desirable that the sediment from former mixtures be thoroughly agitated and mixed in the settling tanks in order to hasten the settling of the new precipitate. To accomplish this result the same steam pump is used that was used for pumping a supply of water into the main. This pump has its inlet connected to branch pipes O (Fig. 3) leading into each of the settling tanks. These branch pipes have their outer ends, P, connected to the main portions by swivel joints. Floats, Q, are secured to each of these inlet ends of the branch pipes to maintain their inlet openings at or near the level of the liquid. The discharge pipe R of the pump is also connected with branches which extend into each of the settling tanks, and such branches are also connected to perforated pipes S, which rest at or near the bottom of such tanks.

The operation is as follows: The valves on the ordinary inlet and discharge pipes, which are used when the mixing apparatus above described is in operation, are closed, while valves T and U on the inlet and outlet pipes just described are opened. The pump is then started and the mixed treated water and precipitate at or near the top of the settling tank, is drawn into the pump through the swivel pipes and forced back into the bottom of the settling tank through the perforated pipes S, thereby maintaining a circulation in the tanks, and stirring up the sediment from former treatments. After the contents of the tanks have been agitated for a few minutes they are allowed to stand until the sediment has settled. The purified water is then taken from the settling tanks through the swiveled pipes and transferred to a suitable storage tank, or it may be drawn direct from the settling tanks to the boiler.

The same size apparatus is used for all plants. The capacity of this apparatus is almost unlimited. The number of oscillations of the tilting vessel is determined by the amount of water that can be pumped into it, so that if settling capacity is provided, the capacity of the apparatus depends entirely upon the capacity of the steam pump. In regard to settling capacity it has been found by using tanks 30 ft. diameter and 16 ft. high that each tank can be filled with treated water, the precipitate allowed to settle, and the clear softened water transferred to the railway supply tanks in 12 hours. These tanks have a capacity of 77,000 gallons, but as a certain quantity of water is left in these with the sludge, their net capacity is about 60,000 gallons of softened water each 12 hours, or 120,000 gallons per tank per 24 hours.

Once a month it is necessary to remove the sludge that has collected in the bottoms of the settling tanks. When the softening plants are located near a drain the removal of the sludge is a very simple proposition. In several cases the plants are not located convenient to drains. It then is necessary to carry this sludge away. Several methods have been tried. One was to dig a hole in the ground near the settling tanks, allow the sludge to run into it, and after the excess water had soaked into the surrounding soil, to shovel the thick sludge out and carry it away. Another was to allow the sludge to run into a large box mounted on a flat car standing on a depressed track located near the settling tanks. This car was then taken to a nearby dumping ground and the sludge allowed to run out. Still another was to pump the sludge from the settling tanks into a box mounted on a flat car standing on a track at the ground level. Still another was to run the sludge into barrels and ship it to various points where it was used.

Up to the present time the only use found for this sludge is for making whitewash. For this purpose it works very well. On account of its firmness and freedom from grit, it is especially adapted for use in a whitewash spraying machine. Last summer the wing fences, telegraph poles, stock-yard sheds, etc., etc., of the Iowa Division of the C. & N. W. Ry., were whitewashed with it. This winter the interiors of the shops at Chicago were covered with it. Experiments are being made to ascertain its value as one of the components of boiler lagging. It is expected that other uses will in time be found for it.

The first of these machines constructed was installed at Council Bluffs, Ia. The water at this point is obtained from four pipes, 4 ins. in diameter, driven into the ground about 70 ft. The apparatus was started July 30, 1902, and has softened all the water used by locomotives at that point ever since. This water untreated is an unusually poor one for boiler use. Several years ago an attempt was made to use it without treatment, but after a few months' trial it caused so much trouble that it was abandoned. The analyses of this water, before and after treatment, at Council Bluffs and Denison, Ia., are given in the table herewith:

	Grains per gallon			
	Council Bluffs, Ia.		Denison, Ia.	
	Wells, 70' deep.		Wells, 25' deep.	
	Before treatment.	After treatment.	Before treatment.	After treatment.
Total solid matter.....	53.67	31.35	24.19	16.50
This solid matter consists of:				
Carbonate of lime.....	24.39	2.26	14.68	2.16
Carbonate of magnesia...	1.18	0.88	2.51	2.05
Sulphate of lime.....	6.22	...	3.60	...
Sulphate of magnesia.....	13.33	...	1.20	...
Oxides of iron & aluminum.	0.34	0.02	0.09	0.06
Silica	1.42	0.38	0.96	0.86
Incrusting solids	46.88	3.54	23.04	5.13
Alkali chlorides..	1.21	1.27	1.15	2.28
Alkali sulphates	5.58	26.32	...	7.77
Alkali carbonates	....	....	....	1.22*
Non-incrusting solids ..	6.79	27.81	1.15	11.37
Pounds of scale-forming matter in 1,000 gals....	6.69	0.51	3.29	0.73

*Alkali carbonates.

The plant at Denison has been in operation about a month. The following are the results of analysis of the water at this station before and after treatment:

In addition to the six softening plants we now have completed, we are erecting 11 more plants, most of which are rapidly approaching completion. At our Chicago shops we are building 25 of the machines, which we proposed to install as fast as completed. We are confident that we have passed the experimental stage of water softening and that in the near future we will remove the lime and magnesia compounds from most of our poor water before they are used in our locomotive boilers, instead of allowing these compounds to be deposited on the inside of the boilers in the form of scale. Briefly stated, we propose to take the scale-forming matter from the water in the shape of a fine white powder and use it for whitewash and perhaps other purposes instead of allowing it to incrust the flues and sheets of the boilers, and then remove it in the shape of hard scale.

PRACTICAL RESULTS IN LOCOMOTIVE BOILERS.

About 35 locomotives take water at Council Bluffs, in 24 hours. Most of these are road locomotives and as they also take water at other stations, it is almost impossible to get definite information in regard to the use of the treated water in them, other than he opinions of the enginemen as to how it acts in the boilers. Their reports have been favorable. Three switch locomotives, however, are worked constantly at Council Bluffs, and have used nothing but this purified water since July 30, 1902. A day or two after they commenced to use it the flues commenced to leak. They were taken into the roundhouse and the flues rolled, and since that time have not leaked nor have they given any trouble. The old hard scale that was in these locomotive boilers is being loosened up by the purified water and comes out in large pieces whenever the boilers are washed out. No new scale has formed. The foreman in charge of the roundhouse at Council Bluffs, under date of Jan. 3, 1903, wrote to his superior officer as follows:

Before using the purified water we had a great deal of flue work on our switch engines, especially the engines doing the heavy work, and will state that we are not doing one-quarter of the boiler work now on these engines that was done prior to using the purified water, and our switching engines are worked very hard at present. For the past two months engine 1,058 has had no boiler work done on her, and engines 171 and 847 have had but little done. These engines are out all the time except when we hold them in once a week for washing out. I am very well satisfied with the water and believe that when once we get the old scales all removed from these engines, calking of any description will be done away with.

The apparatus is simple and inexpensive. It is so nearly automatic that it is only necessary to weigh, dissolve and mix the chemicals and allow them to run into the chemical tank. This is done by an ordinary pumper without interfering with his regular work. It does not require any extra power to operate it. The results of analyses of the water, before and after treatment, show that the treatment is effective, and practical results from the use of the treated water show that it is beneficial to the boilers. With this apparatus the cost of treating waters will vary from a minimum of about 1 ct. per 1,000 gallons for a fair boiler water, to a maximum of say 10 cts. per 1,000 gallons for a water that is so bad that an attempt to use it untreated in boilers would result in so much trouble and expense as to practically debar its use.

DISCUSSION.

Mr. H. E. Smith (L. S. & M. S. R. R.).—In the early days of water softening there was a great deal of difficulty encountered because not sufficient care was taken in making up the solutions and mixing them with the water. I have watched this apparatus that has been described and was impressed with one thing which is not emphasized in the paper, and that is the thorough stirring that the water receives in that triangular tipping box. You can readily imagine a 5-in. or 6-in. stream of water flowing into a box of the capacity of two barrels, and especially one of that shape, would produce a very violent stirring and thorough mixing; that of course mixes the individual charge of water, and the further mixing is completed in the tank, which has been described. The time necessary to complete the reaction and obtain clear water depends somewhat on the water. Carbonate waters requiring chiefly lime can be treated more rapidly than those containing large amounts of sulphate of lime.

Mr. C. L. Kennicott (Kennicott Water Softener Co.).—There is no comparison between the expense of treating the water and the expense of removing the scale from boilers and the lowering of the earning capacity of the locomotive as it lies in the shop in order to cool before washing. Mr. Davidson did not bring out strongly enough the point that if water is purified, if the boilers are not scaled, if the tubes do not leak, that the engines are not held in the shops, in times like these in particular, when there is probably not a railroad in the country but is trying to obtain more motive power; that they would be able to get more time, more earnings out of the engines which they now have, and they would not need so much more motive power.

Another point that was not emphasized is one that perhaps will cause considerable surprise, and that is, the figures which show the enormous amount of scale-forming material which enters locomotive boilers at a given station. Many stations which are not very important run into the boilers every month 5 to 10 tons of incrusting matter. A single division of some of the western roads will run into the boilers as high as 90 tons of scale-forming material every month. These figures, which are quite startling, may be easily proved by figuring from the analyses.

Mr. Robert Quayle (C. & N. W. Ry.).—Some eight years ago we began using soda ash in the water tanks in Wisconsin, and we got fairly good results from its use. When we send a new boiler up onto the Wisconsin Division, they remain 10 to 15 years with never a patch on the sheets; they will go out into Iowa and sometimes in ten months they have to have new side sheets; inside of 18 months or two years they have to have new fireboxes.

Up on the Ashland Division, near the Lake Superior district, we have had one engine running as many as 12 years without having the flues taken out. Through this section of the country we have a great deal of decayed vegetable matter and consequently tannic acid in the water. This accounts for the long life of the flues. I do not believe, however, that it is a good thing to keep flues in a boiler so long. It may be well to do it simply as an experiment, but I believe it to be a good thing to remove the flues every three years or oftener, and make an examination of the inside of the boiler, and examine the sheets, bracing and flues.

Conditions are changing constantly since the introduction of water-purifying plants. The engines that are running from Sioux City into Council Bluffs used to be given a certain quantity of soda ash when they got to Sioux City; we had to discontinue that, because of the soft water that we are now getting at Council Bluffs. From the shop standpoint, the roundhouse standpoint, we are already beginning to find good results.

Prof. Wm. F. M. Goss (Purdue University).—As time goes on and our locomotives become more delicate in their mechanism, and the service expected of them becomes more and more exacting, we shall find it profitable to give large attention to this question of boiler water. The progress from soda ash in the locomotive tender, to purification stations of various sorts, has been rapid. This is a beginnning; I do not think we can see the end of the process. Mr. Davidson's paper brings us up to date, but the future of water purification is all before us. When chemical processes have done what they can, there still remains salt waters to be dealt with. These are abundant in certain portions of our country and will, I believe, be treated by distillation. It is now possible by using some form of series apparatus to supply distilled water for ten locomotives by a fuel expenditure equal to that consumed by one.

Mr. M. H. Wickhorst (C., B. & Q. R. R.).—I have figured that it would cost on an average about 3 cts. per 1,000 gallons for treating the water. Taking that figure as a basis, the cost of furnishing a heavy freight locomotive with treated water would run up to something like $200 per year per engine. Of course, we do not want to spend that amount of money without getting it back again. The principal saving would come in, probably, from the decreased coal consumption and the decreased repairs. A locomotive will burn up, say $5,000 worth of coal a year, and if there is any coal saving at all, we can figure, say, 3%; that would be equivalent to about $150 a year saving on the coal.

The boiler repairs probably in a year run, say, $1,200, and there seems to be no question whatever that boiler repair expenses can be considerably reduced, and figuring that we can cut off 25%, that would save about $300 per year per engine. But another material saving would come from the reduction in boiler washing. In very bad water districts, engines have to be washed out perhaps in some cases as often as every 400 miles, perhaps every 500 or 600 miles; with good water, such as these plants would furnish, that might be extended to at least 3,000 miles; we could save by reduced washouts anywhere from $56 to $100 a year, say, possibly, $60.

Then another very important source of revenue would be the increased use we get out of the locomotive. A locomotive ordinarily is in the repair shop about 10% of the time; then it is out of service in addition, due to washing out and repairs in the roundhouse, probably 5% more, making probably 15% of the locomotive's time as dead time. By having good water we can save the greater part of the time due to washout, and we can save some of the time due to boiler repairs in the shop, and a large part of, or most of it probably, in the roundhouse, so we can save $100 or $200 a year more there, and I figure it as a very conservative estimate that the net saving would probably be $400 per year per engine. I believe, as Mr. Davidson said in his concluding remarks, that railways in the very near future will have to consider these water-treating plants as a part of the equipment of a water station.

Mr. Kennicott.—In connection with the cost of treatment of water, the average of the waters we are now treating with chemicals run a little less than 2 cts. per 1,000 gallons.

THE SAFE COURSE.

By Charles Hansel,* M. Am. Soc. C. E.

No other great industry is served more faithfully and intelligently than the railways. The operating departments of the great railway companies, charged with the safe conduct of the people and property committed to their care, are certainly fully conscious of the duty of carrying traffic with safety and speed. The locomotive driver is selected for his special skill and mental and physical ability, but he is perhaps more influenced by the necessity of making speed than of handling his train with safety. On the other hand, the people who ride on railroads seem to be willing to sacrifice safety to speed rather than speed to safety, and the public as well as the operating officials of the railways must take a share of the blame.

It is quite the fashion now to speak slightingly of English methods, because they seem to us slow and unsuited to the age; but the conservatism of the English public and English railway officials is the most potent factor in securing the splendid results shown by the railways of England during the year 1901. The report of the Board of Trade for that year shows that the railways of England, with a total mileage only about 10% of the total mileage of the United States, carried nearly twice as many passengers, with safety to all. It cannot be claimed that the signal devices now in use in England are superior to ours; and, in fact, it is acknowledged that in many respects the United States has outstripped England in this field; and considerable signal work has been installed in England by American firms.

The writer appeared before the Inspectors of the Railway Department of the Board of Trade in the winter of 1902 for the purpose of discussing the signal systems of the United States and England. During this discussion a report was received by the Chief Inspector, giving an account of an accident in the United States where some 80 or more immigrants had been killed. The writer was asked how it was that such accidents occur in the United States when, as claimed by us, our signal system was superior, and the only answer that could be made was that but a very small percentage of the total mileage of the United States had any system of signaling, and yet as high speed was made on single-track lines without signals in the United States as was permitted on double-track lines in England completely signaled.

The constant desire of the operating officials and the public to make time no doubt influences the action of the locomotive driver to a considerable degree, as he desires, of course, to have a good record for getting his train through on time. To appreciate the influences that guide the actions of a locomotive driver, one must study the conditions from the cab of a locomotive, and I fancy that if more people were familiar with these conditions there would not be such a desire for speed at the sacrifice of safety. It is not likely that any argument of this character will change the temperament of a nation, and we must, therefore, view the conditions as they exist and endeavor to guard against the involuntary or inexplicable acts of the locomotive driver, who, while possessing keen intelligence and a desire to do his duty to the public and his employer, occasionally fails for reasons that in many cases he himself cannot explain.

Two accidents have recently occurred with horrifying results, and in each case the railroads were equipped with as good a system of visual signals as is known to the art, and it was clearly proven that these signals were operative and indicated the exact condition of the block they governed. These accidents demonstrate that the locomotive driver must be protected against the time when he shall fail from mental or physical inability or from inattention, and it can hardly be expected that any human being will always do that which he ought to do.

It is believed by some that the addition of a third man on the locomotive would be a satisfactory protection against accidents. This is questionable. In the case of the Westfield collision, the locomotive driver was separated from the fireman, and the opinion has been freely expressed that had there been a second man in the cab with the locomotive driver, the accident would not have occurred. In the case of the Fourth Ave. tunnel accident, the locomotive driver and fireman were together, and the evidence brought out the fact that the fireman called the attention of the locomotive driver to the condition of the signals, but apparently did nothing further. Immediately preceding the collision in the Fourth Ave. tunnel, the fireman stood in the same relation to the locomotive driver as a second man in the cab of a locomotive of similar construction to that involved in the Westfield wreck.

Having had this experience of two serious accidents under the conditions named, it does not appear that the presence of another man on a locomotive would materially guard against such accidents.

For many years inventors have sought devices for the automatic control of trains by means of apparatus beyond the reach of the locomotive driver, and have fixed the predetermined points on the permanent way so as to apply the air brakes in case the train attempted to pass that point when the signal was at danger. Up to the present time none of these devices provide for all of the necessities of railway operation. Any such device should be considered in relation to the carrying of traffic safely without unnecessary interruption. No devices should be encouraged which will tend to remove the responsibility from the locomotive driver of observing visual or other signals, which are called fixed signals on the permanent way, and it should only become automatically operative when the locomotive driver becomes, as it were, "de-energized" physically or mentally, or both. He should retain the control of his train at all times so long as he is "energized" and fit mentally and physically to perform the functions of his post. He should be able to pass a signal at danger, provided, however, there is no obstruction in the block or section of track it governs, or in case he has a permissive card authorizing him to proceed under control past a home signal, or whenever he knows a signal is at danger because it is out of order, and there may be other conditions which may make it necessary for him to pass a home signal at danger in order to protect his train. He should be able to hold the apparatus from operating automatically where there is no occasion for it to do so, but in case he does hold the apparatus from operating, such acts should be recorded as to time and frequency in such a manner as to make a secret record beyond his control to change. The apparatus should be sufficiently elastic to provide for all or any of the following operations:

First. The automatic shutting-off of steam.

Second. A definite reduction in the air brake train line or equalizing reservoir.

Third. An audible signal sounded in the cab simultaneous with the reduction of pressure for the application of air brakes.

Fourth. The automatic and secret recording both as to frequency and time of the operation of the mechanism on the locomotive, which gives any or all of the above-named results.

Fifth. The automatic and secret recording by time and number of any act on the part of the locomotive driver, which prevents the automatic operation of all or any of the devices referred to.

Sixth. The automatic and secret recording of each time a locomotive passes a home signal at danger, even though the signal may be at danger because it is out of order.

I believe it is entirely practicable to give all of these results without interfering with the proper and independent action of the locomotive driver so long as he is competent to act, and such devices may be so arranged in connection with the locomotive as to not inconvenience him and provide against the time when he may fail to do that which he ought to do. There is, of course, a great diversity of opinion as to how far we should attempt to carry the automatic control of a train, and it may be that in the opinion of some operating officials it would only be necessary to automatically shut off the steam and give an audible signal in the cab, whereas others might desire all of the functions above indicated. In any case, the automatic control should be used as an auxiliary to fixed signals and governed by the condition of the block, in which case it would protect the train against a false indication of the signal, which sometimes shows clear when it should be at danger.

By using the automatic control system as an auxiliary in the manner described, the equipment of each locomotive and block increases the unit of safety, and even though but one locomotive be so equipped, we have taken a permanent forward step which insures the control of that train just as surely as if all the locomotives were fitted, and all additional locomotives so equipped adds to the percentage of protection. It is evidently not necessary to have a definite percentage of all the locomotives equipped before we can secure the benefit of the apparatus as in the case of the air brake system.

Assuming that a railway thoroughly equipped with a semaphore block system has also added the proposed system of automatic control, the locomotive driver, instead of feeling that he is relieved from the responsibility of observing the visual signals as closely as heretofore, finds that he must use greater vigilence, because a record is made of each time he passes a home signal at danger, and with the knowledge that that record is in the hands of his superior each day, he will certainly hesitate to sacrifice safety to speed.

The failure of the automatic control system is not by any means as serious as the failure of the visual system, because it is only an auxiliary, and as the engineer has to depend upon the indication given him by the visual system to advance or stop, there is nothing in the automatic control system which authorizes him to advance.

*Broad-Exchange Building, New York City.

THREE TOPOGRAPHIC ATLAS SHEETS have recently been completed by the U. S. Geological Survey and are ready for distribution at the regular price. They are: (1) The Norwich atlas sheet, giving topography of Chenango county, N. Y.; (2) the Bradshaw Mountain atlas sheet, covering an area of 1,000 sq. miles in Arizona; (3) the Velpen quadrangle, comprising parts of Pike and Dubois counties, Indiana.

THE CINCINNATI, GEORGETOWN & PORTSMOUTH R. R. in Ohio, which was built in the '70's as a narrow-gage steam railway, has recently been changed to a standard gage and electric traction has been substituted for steam. The line is 50 miles in length and is equipped with a three-phase high-voltage transmission system, there being three substations besides the main power station. Although the railway runs on its own right of way, current is taken from an overhead trolley wire and it is intended to attain a speed as high as 40 miles per hour. The power house has a capacity of about 2,000 HP. The rolling stock consists of 22 passenger cars and six combination cars and an hourly service is maintained. The electrical equipment of the road was furnished by the Westinghouse Electric Co. Mr. E. M. Stevens is General Superintendent of the company, and Mr. Jos. Bryan was the engineer in charge of the electrical equipment of the road.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

Rumors as to the make-up of the Isthmian Canal Commission appear from time to time, but we hear nothing that is authentic save evidence that the President is likely to exercise great care in the selection of its members. Apropos of this the Louisville "Courier-Journal" says:

> The expenditure by the government of so colossal a sum as the canal is sure to cost would not be possible without exciting the greed of that class of men who always inquire of every public enterprise what there is in it for them. Undoubtedly, there are great fortunes in this project for some men if they can only succeed in controlling it. Accordingly, it is not surprising to learn of the organization of the world's largest construction syndicate, made up of financial leaders, which is to bid for the construction of the canal. Questions of this sort will have to be resolved by the commission yet to be appointed. But the advantage of being early in the field and so influencing appointments if possible, is obvious enough.

The country relies on President Roosevelt to see to it that no member of the Panama Canal Commission is appointed through any influence which will place him under obligations that he will afterwards have to repay. It is important that men be selected for the commission of sufficient technical and business ability to successfully deal with the important questions which the commission will have to decide. It is even more important, however, that the members of the commission shall be men of such personal and professional reputation that their honor and honesty shall never be questioned. It will be a national shame if we undertake this great work as a Government enterprise and repeat the record of corruption and dishonor made by De Lesseps' unfortunate company. It is not too much to say that the result hangs in large measure on the President's good judgment in selecting the members of the commission.

We discussed in our issue of Feb. 19 some of the essentials of a successful automatic stop system for use in connection with fixed signals on railways. Since that publication several prominent signal engineers have expressed to us their thorough approval of the principles which we laid down.

On another page of this issue we publish a paper by Mr. Chas. Hansel, M. Am. Soc. C. E., the well-known signal engineer, in which the design of a successful automatic stop system is further considered. Mr. Hansel lays stress on the fact that an automatic stop system must be adapted to practical conditions of railway operation. Many inventors who have worked on this problem have erred in trying to make their devices practically supersede the engineer. We may as well face the fact that no train is safe or can be made safe without the constant and continual care of the engineer, and no automatic mechanism can take his place, save for a few moments to perform a single act. With the engineer careless or neglectful, the water may fall in the boiler, or may rise until water in the cylinder causes a wreck; dangerous speed may be attained from failure to properly handle the brakes or the throttle and reverse lever or the air pressure in the brake system may be frittered away so that the automatic stop system itself will fail to operate.

As Mr. Hansel plainly shows, a successful automatic stop system must be designed to be a check on the engineer and not to supersede him or relieve him of his present responsibilities.

The Clifton Ave. grade crossing disaster of Feb. 19, in Newark, N. J., in which 9 school children were killed and 50 were injured, has resulted in the indictment by the Grand Jury of the Executive Committee of the Board of Directors of the North Jersey Street Ry. Co., and of the President, Vice-President, Roadmaster, General Superintendent, Division Superintendent and Assistant Superintendent of the company. It will in all probability be found, if the indictments are brought to trial, that no proof of criminal carelessness can be presented against any of these officers. The fact is that the whole public is "particeps criminis," as the lawyers say, and is culpable for permitting the creation and use of such standing invitations to accident as a grade crossing of electric and steam railway tracks. There are hundreds of such grade crossings in use to-day every whit as dangerous as was the Clifton Ave. crossing. It was only chance that caused a fatal accident to happen on this particular grade crossing in Newark instead of on some one of these hundreds of others. These indicted men, from this point of view, are no more guilty of crime than many other men who have equal responsibility for other grade crossings. The indictments, however, may serve a useful purpose by calling renewed attention to the dangers of such crossings and to the fact that somebody is responsible for their existence.

About the most difficult material to drive tunnels through—if we except submarine tunneling work—is loose sand or gravel; and comparatively few tunnels have ever been made through such material. For this reason the work on the Michel Creek Loop Tunnel, on the Canadian Pacific Railway's new Crow's Nest Pass line, is well worthy of permanent record. The article descriptive of the work, which we print in this issue, was prepared for Engineering News by an engineer connected with the work; and his account of the methods adopted for coping with the various difficulties which were encountered, is particularly interesting. One very ingenious scheme was the rigging of an improvised cable scraper, by which some 30,000 cu. yds. of gravel were hauled down a side-hill and placed where it could not threaten the railway line. The idea may prove suggestive to other engineers who encounter difficulties in connection with side-hill excavation.

The water meter has had many sins charged against it, but few of its alleged crimes are more amusing than the allegation that it "furnishes a breeding place for typhoid fever germs." This accusation has recently been seriously made at Cleveland, O., and has been taken in earnest sufficiently to cause some one to compile the typhoid fever statistics of cities having many meters in use in order to disapprove the assertions regarding the connection between meters and typhoid. A little later some of the good people of Rochester, N. Y., expressed alarm over the same subject. To reassure the public on this point a reporter of the Rochester "Union-Advertiser" visited the office of Mr. J. Y. McClintock, Commissioner of Public Works, and examined a couple of meters. According to the paper named "it was possible to see at once that there was no chance for fever to generate in the meters."

Those whose knowledge of the habits of the typhoid "bug" makes them fear that it will pause to lay its eggs while passing through a water meter should remember the like probabilities that the "bug" would be caught in the water meter's mechanism and squashed into innocuous desuetude.

The American Institute of Electrical Engineers is growing more rapidly than any other of the national engineering societies. Its catalogue of members, issued on Jan. 1, shows a total membership of 1,763, and between Jan. 1 and Feb. 6 there were 57 new members elected and qualified in the Associate grade. Besides this a pamphlet "announcement of coming meetings," etc., issued by the Society on March 27, bears a list of 212 candidates for admission to the Society, whose applications are now pending. At this rate of progress the Institute's roll of members will soon surpass those of the Civil and Mechanical Engineers' Societies, which have each something over 2,500 members on their rolls.

Among the reasons for rapid growth of the Society we may note among others the moderate rate of dues. The initiation fee is only $5 and annual dues are $10 for associates and $15 for members. Over three-fourths of the membership is in the associate grade, and entrance to the society can take place only through the associate grade, members being created by transfer from the ranks of associates. Both elections as associate and transfers to full membership are entirely in the hands of the Board of Directors of the Institute. Published lists of applications on file before the Board are distributed to the membership from time to time, with invitations to submit to the Board objections to any candidate, but the final election of candidates is by the Board and not by the membership at large.

Another thing which is undoubtedly stimulating the growth of the Institute is its local meetings, on which we have recently commented. The bulletin before us gives reports of the proceedings of local branches at Chicago, Philadelphia, St. Louis, Lafayette, Ind.; Allegheny, Columbus, O.; Champaign, Ill.; Ithaca, N. Y.; Boston, Denver and Columbia, Mo. The meetings at Chicago, Philadelphia and St. Louis were held at the headquarters of the local engineering society in each case. Those at each of the other places named were held in connection with the universities located at each place, except at Denver, where the hall of the Denver Gas & Electric Light Co. was used. In the monthly "Transactions" of the Society, reports of the discussions at these local branches are printed.

It is very well known that one of the difficulties in persuading men to apply for membership in an engineering society is fear of rejection. This is particularly the case with men of wide reputation and long experience, since such men are very likely to have made at some time or other in the course of their life personal enemies who will improve such an opportunity for revenge. In the case of the American Society of Civil Engineers and the American Society of Mechanical Engineers, only seven negative votes are required to defeat a candidate. In the American Institute of Mining Engineers one-fourth the votes cast must be in the negative to defeat a candidate, and in the Electrical Engineers, as above noted, the election is taken out of the hands of the members entirely.

In our opinion this last is the wisest course. The "blackballing" of applicants for admission is all right in a social club, since the entire purpose of such an organization hinges upon its members being personally agreeable to each

other. A national engineering society, however, is very far removed from a social club. Professional and not personal qualifications should be the controlling factor in election to membership in such an organization; and the governing body of such a society is much better equipped to pass upon these than are the members at large.

Another very important move ordered by the Board of Directors of the Institute of Electrical Engineers on March 27, is the creation of a "Student" grade. This grade does not correspond to the "Junior" grade of the Civil and Mechanical Societies, but is intended for young men who are actually students, either at the technical schools or elsewhere. The sole requirement of applicants for such student membership is that they shall be "regularly pursuing electrical studies." Such men on endorsement by some Member or Associate of the Institute, recommendation by the Board of Examiners and approval by the Board of Directors, may on payment of $3 per annum become Students of the Institute, and as such will receive the regular announcements and monthly "Transactions," and may attend any meetings of the Institute except business meetings. They may also purchase the semi-annual bound volumes of "Transactions" at $3.50 per volume. The continuance of such student membership is limited to not more than three years in any case.

We commend the sagacity of the Institute managers in this latest move. In connection with the local meetings of the Institute now held at fourteen different prominent engineering schools, it will doubtless serve to bring into connection with the Society a large number of young engineers and a considerable proportion of these will be apt to apply for membership in a higher grade on completing their studies and beginning active practice.

Crude and misconceived as are some of its interpretations of water waste prevention measures in Europe, Mr. Johnson's report to the Merchants' Association of New York, abstracted elsewhere in this issue, contains much information of possible value. We say possible value, for a large part of the good matter is in danger of being nullified by a strange lack of appreciation of some of the most obvious features of water-works problems and practice at home and abroad. True, many of the facts, and practically all the teachings of the report, so far as they relate to water waste, are already well known to American engineers, but the general public is for the most part still ignorant of the rigid control of water consumption in Europe, and it can best be reached by public-spirited organizations like the Merchants' Association. The great danger, however, is that such bodies of laymen, in dealing with technical subjects, will prove to be blind leaders of the blind, as is so nearly true in this particular case. The report in question must have cost somebody many hundred dollars. The same time and money, with the aid of a man already well posted on American and European water-works practice, might have been made ten times more effective. But the report brings out most clearly the fact that water waste can be held in check, differ as people may as to the best means to that end. It only partly shows why, irrespective of waste prevention, water consumption is so low in Europe, as compared with America. It entirely misses, so far as the author's interpretations are concerned, some of the fundamental principles of waste prevention; and the author also fails to grasp the fact that water meters, aside from all questions of consumption and waste, are a necessity if the cost of the water-works service is to be equitably apportioned. Fortunately, Mr. Johnson's own words, as well as those of his chief witnesses, go far towards correcting his false impressions, as may be seen from the abstract which appears elsewhere in our columns.

Mr. Whitaker Wright, a gentleman whose exploits in high finance in connection with mining companies, particularly those of British Columbia, have brought him into conflict with the laws of Great Britain, is at present residing in Ludlow St. Jail, New York city, awaiting extradition proceedings for his transfer to the jurisdiction of a British court. We would not say a word to obstruct such a transfer, and yet it does seem a pity that we can't swap Wright for Greene and Gaynor! Certainly the legitimate mining interests of Canada have so suffered from Wright's exploits that that country is interested in his punishment, and ought, in return for our prompt capture and detention of Wright, to coop up Greene and Gaynor and ship them back to our side of the boundary line.

THE PROGRESS OF THE NEW YORK BARGE CANAL BILL.

The New York 1,000-ton barge canal bill passed the Assembly on March 26 by a vote of 87 to 55. Its passage in the Senate by a vote of 32 to 14 was noted in our last issue. The votes in favor of the bill in the Assembly were cast by 33 Republicans and 54 Democrats, and those opposed to the bill by 51 Republicans and 4 Democrats. It is thus evident that public sentiment on the bill divides on other than party lines, and this fact is of interest in canvassing the chances of the success or failure of the bill in the referendum vote which is to be taken on the measure at the election next November.

The bill was carried through the legislature by the strength of the delegation from New York city, most of which is Democratic. If the support of that party continues to be given to the measure, it will insure a heavy vote in favor of the bill from the voters who follow this party's ticket in New York city. There will also, doubtless, be a large vote in its favor from the Republican voters in New York city, and the votes controlled by the labor organizations will be largely cast for the bill on the ground that it will cause an enormous amount of money to be spent which will furnish employment. Buffalo can also be counted on to cast a heavy majority in favor of the bill.

On the other hand, the discussion in the State press and the vote in the legislature has made plain the fact that a very strong opposition to the measure exists in all parts of the State outside the two great cities at the terminals of the canal, and this opposition is particularly strong in the farming districts. Notwithstanding the fact that the platforms of both parties at their State conventions last fall took strong ground in favor of the barge canal enterprise, a majority of the Republicans in both branches of the legislature voted against the bill on its final passage, and it is acknowledged by a leading advocate of the canal measure that the Republicans voting against the bill included the ablest and most prominent of the party leaders. Besides this it is to be noted that several prominent Democrats voted against the measure in deference to the known sentiments of their respective districts, and notwithstanding the unequivocal declaration of their party platform in favor of the measure.

Turning now to the figures of election returns, it is of interest to note that in the last State election the combined vote for all candidates cast in the counties which include New York city and Buffalo (these counties being New York, Kings, Queens, Richmond and Erie), was in round numbers 633,000. The total vote of the balance of the State was in round numbers 747,000. Of this total it will not be far from correct to assign to counties located along the line of the canals enough to make the population of Greater New York and Buffalo about equal to the country population located in districts where sentiment is known to be adverse to the canal.

From present appearances it seems a fair supposition that the vote in the counties along the canal route will be about evenly balanced for and against the bill. If this should be the case, the final result will turn on whether the votes against the canal proposition in the Greater New York counties and Buffalo will overbalance those cast in favor of it in what may be called the anti-canal counties.

Some light on the probable results of the coming referendum vote may also be gained by recalling the $9,000,000 canal appropriation adopted by popular vote in 1895. This appropriation was unanimously approved by the press throughout the State. Both political parties were united in its favor. No word of opposition was raised to it, so far as we recall, in the entire campaign, and yet a large vote was cast against it. The majority in favor of it was 275,000; but the total vote of the State in that year was about 1,150,000.

Another point which should not be overlooked by one who would forecast the result of the referendum is the fact that the forces which are working for the barge canal project are thoroughly organized. The success attained in the legislature has been unquestionably due to this organized and systematic effort, which first succeeded in committing the conventions of both political parties in favor of the scheme and then compelled the carrying out of these pledges. This same organization is to undertake a wholesale educational campaign among the voters of the State before the fall election, and will certainly see to it that every available argument in favor of the enterprise is spread before the people.

When we look for organized opposition to the measure, we find absolutely nothing. A number of independent newspapers and a large proportion of the members of the legislature have opposed the barge canal bill, and have reflected public sentiment throughout a large part of the State in so doing, as already noted. It remains to be seen whether these elements will crystallize into an effective organization to conduct a campaign against the measure and enlighten voters as to the other side of the case. The chances, however, seem rather against it, for opposition to the measure is nobody's particular business. On the other side, the grain and produce and shipping and elevator interests of New York and Buffalo, which have large interests at stake in the canal bill, form a strong nucleus, and this gathers to itself the political interests which want to control the spending of $101,000,000, and the labor interests which want the employment which it would furnish. On the opposite side the only interests at stake are those of a few hundred thousand taxpayers; and their ground for opposition is to be taken away by the assurance that the canal work will be paid for out of taxes on corporations, or liquor dealers, or some other indirect form of revenue.

Under these circumstances we look for no strongly organized opposition to the canal bill. If defeated, as we are still inclined to think will be the case, it will be by the "silent vote."

All these matters have nothing to do, of course, with the merits or demerits of the barge canal as an engineering work, which we have discussed at length in recent issues of this journal, and which we shall further discuss from time to time during the campaign. We may note here, that the position of the legislature in passing the bill can hardly be considered an approval of the project. The strongest argument presented to the legislators was that the matter should be turned over to the people to decide, and that both political parties had practically promised to do this in their platforms. Had the responsibility rested entirely with the legislature, it is very doubtful whether the bill could have been passed.

LETTERS TO THE EDITOR.

Hydrography and Hydrology, as Related to the Work of the U. S. Geological Survey.

Sir: During the growth of a science or an art it becomes necessary to coin new words to express various shades of meaning and to differentiate clearly between words which at the outset may be nearly synonymous.

The words geography and geology have during the course of time come to assume distinctive meanings, although it is even now impossible to draw a sharp line between their respective provinces. The geographer is sometimes inclined to make the definition of geography so broad as to include all that is meant by geology, and the geologist on the other hand may make geography merely a discussion of the latest phase of geologic history.

The words hydrography and hydrology have not yet taken distinctive meanings, and are used interchangeably by some writers and synonomously by others. It is, however, desirable to have two words expressive of dif-

ferent branches or subdivisions of the study of the water resources of the earth, and therefore, in the organization of the investigations being carried on by the Geological Survey, a somewhat arbitrary difference has been assigned to these words.

Following the analogy between the words geography and geology, it has been decided to include under hydrography those matters which pertain to a description of the surface streams and other bodies of water, while under the term hydrology has been included those investigations which relate to the geologic phenomena governing the occurrence of waters beneath the surface.

The Hydrographic Branch of the Geological Survey has been organized into three divisions, the first being the Division of Hydrography, having to do with the measurement and investigation of surface streams; the second is the Division of Hydrology, investigating the occurrence of underground waters; and the third, the Reclamation Service, to carry on the engineering operations leading up to the construction of reservoirs, canals, and similar or associated works.

For the operations of the Divisions of Hydrography and Hydrology, the sum of $200,000 has been annually appropriated. The data acquired have practical bearing upon the development of the water resources of the country, and also are of fundamental importance in the plans of the reclamation service.

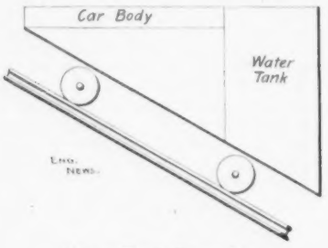
An excellent opportunity for young engineers and geologists is offered in this new and growing field where conditions heretofore unknown are being made clear, and explorations carried on into the laws which govern the occurrence of water. Very truly yours,

F. H. Newell, Chief Engineer.

U. S. Geological Survey, Washington,, D. C.,
March 17, 1903.

A Water-Tank Car for Gravity Tramways.

Sir: With reference to the note in your issue of March 19 on "A Novel Gravity Tramway," Messrs. Fisher & Le Faun, contractors for the Manchester water-works, England, have used a gravity road somewhat similar to the one described, only they use two cars like the one in



Water-Tank Tram Car.

accompanying sketch. The water tank holds something over three tons, and the cars take about three tons. They use these to take stuff up and down the grade. The tanks are filled at the top of the grade and emptied at the bottom after the car is loaded. The foreman on being asked how they worked after they were installed remarked that they "Go up like flames of fire."

Yours truly, F. Breakey Freeman.

Co-operation Between National and Local Engineering Societies.

Sir: I have been greatly interested in your remarks about co-operation between our engineering societies, although it seems to have been chiefly directed toward co-operation between our national societies. Is it not possible to bring about some form of co-operation between the national societies and local societies now in existence? Why, for instance, should the members of the national societies co-operate to form a local society, as at Schenectady, if one is already in existence? But if a local society is in existence, the fact that one is a member of a national society does not help him. If he wishes to join the local society he must apply in the same manner and pay the same entrance fee as those who are not members of a national society. Would it not be well for our local societies, in self-defence against the founding of local chapters or branches of the national societies, to make some concession to the members of such societies? I would suggest that the local societies dispense with balloting on the names and with the entrance fee from applicants who are members of any one of the national societies. Whether a national society should make any concession to members of local societies applying for admission I leave to others. Truly yours,

F. V. McMullin.

Pittsburg, Pa., March 30, 1903.

(While we believe that applicants for membership in a national society should not be voted on by the society at large, we also believe that in a local society such balloting is a wise and proper rule. In the case of a candidate for admission to a national society, the chances are that not one in a hundred of the members entitled to vote knows the candidate or has ever heard of him. In a local society, on the other hand, particularly in the smaller cities, it is usually the case that an applicant for membership is known either personally or by general reputation to nearly all the members. Further, membership in a national society is as a rule and rightly, dependent chiefly on professional qualifications (including in this of course a proper record for professional honor and honesty). If a man has the professional standing to qualify him for admission to one of the national societies, he ought not to be excluded because of other personal qualities or their lack. His fellow members will probably meet him socially in connection with society meetings only at very rare intervals if at all. In a local Engineers' Club, on the other hand, the case is entirely different. Such an organization, like any other social club, can only lead a prosperous existence if its members are reasonably congenial to each other. Hence the general ballot on new members in such societies is a useful safeguard.—Ed.)

The Septic Tank Patents Again.

Sir: Can you inform me as to the present legal status of the septic tank question? Can no one build and operate a properly constructed septic tank, without paying a royalty to the Cameron Septic Tank Co.? Or do their patents cover only certain special devices, not absolutely essential to the proper working of the tank? If so, can you specify what those devices are?

My impression is that these questions have been made the subject of test cases in the courts, but I have not followed the matter closely enough to know what decisions have been rendered. Any information which you can give me upon this subject will be much appreciated.

Yours truly, Inquirer.

New York, March 4, 1903.

[So far as we know, the Cameron patents have not been passed upon by the U. S. courts, nor any suit brought by the Cameron Co. to test them. There is, however, a suit now pending against the city of Plainfield, N. J., brought by the American Sewage Disposal Co., of Boston, Mass., Mr. John N. McClintock, President and Manager. Mr. McClintock claims that the septic tank and double filtration beds at Plainfield are an infringement of Patent No. 559,522 (May 5, 1896), granted to the late Amasa S. Glover, and now controlled by the company named. He also claims that the principles underlying the septic tank were discovered by Mr. Glover prior to September 7, 1881, and before the date of the French patent on the Mouras automatic scavenger, and that U. S. patent No. 258,744 (May 30, 1882) covered septic action. The patent granted the Cameron interests in this country is No. 634,423 (Oct. 3, 1899), and covers anaerobic action in the absence of air, light and agitation for liquefying the solid organic matter in sewage. It also covers subsequent aeration, and includes submerged inlets and outlets, and various details of the same. The Glover patents have been discussed, mostly by correspondents, in Engineering News for Dec. 7, 1899, Feb. 7 and 21, and March 28, 1901. Finally, there is an interesting and valuable paper on "The Antecedents of the Septic Tank," by Mr. Leonard Metcalf, M. Am. Soc. C. E., in Vol. XLVI. (Dec., 1901) of the Transactions of the American Society of Civil Engineers.—Ed.]

Another Engineer's Experience with Contracts and Contractors.

Sir: I have been a good deal edified by the discussion regarding the drawing and enforcement of contracts.

As I have been the engineer of railway companies which have been sued on my estimates some eight or ten times, if I haven't learned anything, I must have been a poor scholar; and I think I can give my engineering friends a few valuable tips as to contracts.

As a general proposition, exemplary or actual damages cannot be enforced against a contractor for exceeding a "time limit" unless he be given a premium for getting it is work done before his limit expires. The courts look upon the matter as a kind of "I get the turkey and you get the buzzard," or "You get the buzzard and I the turkey" affair.

A case of this kind narrows to this proposition: The company holds back final payments and the contractor sues. The court will permit the contractor to prove that he used due diligence; that he couldn't get material; that the elements were against him, etc. Human beings are not responsible for "riot, insurrection, rebellion, the acts of God, or the enemies of the King." A contractor's shrewd lawyer will, by hook or crook, make this rule apply so it will become a question of fact for a jury, and the company is beaten.

There is one way that this matter can be certainly reached, and that is by inserting in the contract the following:

If, in the opinion of the engineer, the said contractor with the force and plant employed, will be unable to complete the work within the time specified, then said engineer shall notify said contractor in writing to what extent said force and plant shall be increased, and if said contractor shall fail within ten days to make said increase, then said engineer may make such increase, charging to said contractor the cost thereof and paying to said contractor his contract price for said work.

The above will hold water and is a cinch.

Another trouble breeding matter in all specifications is classification. The contract reads beautifully, that the engineer's judgment shall be binding on both parties and neither shall dispute it, etc.; this applies to any other quantities as well.

The contractor loses money and lays it to the engineer instead of to his awkwardness and sues the company. The clause in the contract is no protection whatever. The contractor alleges fraud and mistake and opens up the whole question, which is a question of fact for the jury, and you are beaten again.

Under the general rule of law, the burden of proof is on the contractor to prove fraud and mistake; but it doesn't work out that way as a matter of fact. The contractor's engineer (there are shysters in the engineering profession) demands your notes. You refuse. Then he can do one of two things, both of which are against you. He can make a tremendous handle of the fact that you dare not show your notes, or he gets a "subpoena duces tecum," and compels you to let him have access to them. Nine times out of ten he can throw doubt upon the accuracy of your judgment. It takes mighty little for him to get a verdict against a corporation.

The next "trouble breeder" is that exasperating thing known as "overhaul." I have never yet been able to convince a court, jury or contractor that the average haul is the distance between the centers of gravity of the two masses. Suppose that free haul is 500 ft.; find out at what points in end of cut and end of fill will make 500 ft of grade; then finding center of gravity of balance of cut, find distance to center of gravity of the bank it will make. If you give the contractor 900 ft. of overhaul, he will swear he hauled some of it 1,600 ft., and make you admit it, and you get stuck again.

In my judgment Mr. Trautwine's proposed clause (Eng. News, March 5, p. 216) is absolutely inoperative. If I am right, it "presumes a legal conclusion" which you are never permitted to prove.

For instance, a man gets hurt. The first question asked him may be: "Who was the foreman?" He will not be permitted to answer that question. He can tell who was there and what they were doing, and the court and jury will determine who the foreman was.

A stronger parallel case was decided by the Supreme Court of Wisconsin in line with Mr. Trautwine's proposition. A railway was to be completed within a certain time in order to get $30,000 of bonds voted by a county. It was not completed within a month of the time limit, but the court held it was a "substantial compliance" and that the county was not damaged by the delay.

Your editorial comment is correct and to the point. What is the use of encumbering contracts and specifications with clauses not to be complied with except in emergencies? It is exactly on the line of the farmer's opinion of prohibition: "He was in favor of the law, but agin its enforcement." After 30 years' experience I have concluded that a short, concise, specific contract, fair to both parties, is the thing, avoiding every clause possible that might be misconstrued.

The most satisfactory contract I ever let, was for 16 miles of railroad, wherein I paid a flat price per cubic yard for the material both in bank and cut; permitted the contractor to waste, borrow or haul as he pleased, and his price per yard included clearing and grubbing. The only outside clause I had was one permitting me to put on the force and do the work if he didn't.

It can be set down as a fact that no "summary clauses" inequitable on their face will be enforced by the courts against a contractor. We will be beaten on the ground of "against public policy," if in no other way.

E. T. Abbott.

207 Globe Bldg., Minneapolis, Minn., March 9, 1903.

Concerning Stiffeners for Columns.

Sir: At one of the large bridge and structural shops in Pittsburg last summer, the writer was informed that instead of grinding stiffener angles to fit the curved fillet of flange angles, this shop has adopted the practice of beveling the stiffener, as shown at A in Fig. 1. The labor-saving advantages of this practice are apparent; but if a stiffener treated in this manner is intended to carry a load applied on top, as in the case of a stiffener for a column

bracket, there are two requirements to be met which might be easily overlooked:

(1) The area of outstanding leg of stiffener must be sufficient to bear the entire load.

(2) The rivets which hold the stiffener in place must be calculated to resist the moment W L of the eccentric load (Fig. 2) unless the stiffeners are arranged in pairs, back to back, as in Fig. 3.

The load W applied on the outstanding leg of stiffener tends to cause rotation about the center of gravity of the

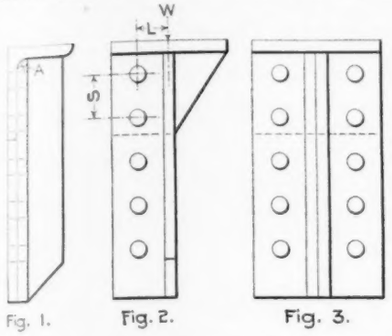


Fig. 1. Fig. 2. Fig. 3.

line of rivets, and at the same time produces shear on the rivets in a vertical direction.

The following solution for the value of W (Fig. 2) is based on the obvious fact that if the maximum force in end rivets does not exceed the safe value R, the connection is safe.

Let
p = tangential force due to moment W L on one rivet at 1 in. from C. G. of the group; and
z = distance to any rivet from C. G.,

then
pz = tangential force on same; and
pz^2 = moment of this force;

therefore

$$p \Sigma (z^2) = p I = M = W L,$$

and

$$p = \frac{M}{I} = \frac{W L}{I};$$

I being the moment of inertia $= \Sigma (z^2) = \Sigma (a^2) s^2$,

$$a = \frac{z}{s}.$$

Let

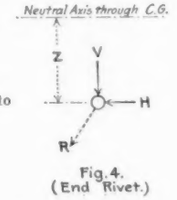


Fig. 4. (End Rivet.)

N = number of rivets;

$$H = p Z = \frac{W L Z}{I},$$

Z being distance from C. of G. to end rivet;

$$V = \frac{W}{N}; \text{ (see Fig. 4,)}$$

then

$$R^2 = H^2 + V^2 = \frac{W^2 L^2 Z^2}{I^2} + \frac{W^2}{N^2} = \frac{W^2 (L^2 N^2 Z^2 + I^2)}{I^2 N^2},$$

therefore

$$W = \frac{R I N}{\sqrt{L^2 N^2 Z^2 + I^2}}, \qquad (1)$$

Let $I = A_s^2$; $A = \Sigma (a^2)$.

The values of A are given as follows:

N	A	N	A	N	A	N	A
1	0.0	7	28.0	13	182.0	19	570.0
2	0.5	8	42.0	14	227.5	20	665.0
3	2.0	9	60.0	15	280.0	21	770.0
4	5.0	10	82.5	16	340.0	22	885.5
5	10.0	11	110.0	17	408.0	23	1,012.0
6	17.5	12	143.0	18	484.5	24	1,150.0

For example, take the stiffener shown in Fig. 2.

Let
L = 2;
S = 3;
N = 5;
R = 4,000 = single shear on ¾-in. rivet;
$I = A_s^2 = 90$;

$$W = \frac{4{,}000 \cdot 90 \cdot 5}{\sqrt{4 \cdot 36 \cdot 25 + 90^2}} = \frac{1{,}800{,}000}{108} = 16{,}660.$$

for the value of S, N and R, just assumed,

$$W = \frac{4{,}000 \cdot 90 \cdot 5}{\sqrt{36 \cdot 25\, L^2 + 90^2}} = \frac{1{,}800{,}000}{\sqrt{900\, L^2 + 90^2}}. \qquad (2)$$

From the general equation (1) special equations similar to (2) can readily be derived for any number of rivets, and assuming customary values for the constants R and S, a very useful and interesting table can be made covering all ordinary values of L and N.

John L. Hall.

1553 Monadnock Block, Chicago, Feb. 26, 1903.

(The practice noted by Mr. Hall is followed at many bridge shops, the stiffeners being ground to a bevel on emery wheels. For important work, however, some shops mill the stiffeners to fit the fillet of the flange angles, as described in our issue of March 3, 1898.—Ed.)

A Formula for Designing Hooped Concrete Columns.

Sir: M. Considère in the laboratory of L'Ecole des Ponts et Chaussées has made an elaborate series of tests on hooped concrete columns, the results of which promise to be of considerable importance in the future construction of reinforced concrete columns. The following conclusions have been deduced from those tests: (1) Hooped concrete columns are considerably more ductile than columns which are only reinforced by longitudinal bars; (2) the efficiency of the hooped reinforcement is 2.4 times that of the longitudinal reinforcement. On the basis of Considère's experiments we have designed some concrete columns reinforced with hoops, with the help of the following formula:

$$l = \frac{H}{2.4\, k\, S} [f L - A C - a S],$$

in which

l = total length of hooped bar in feet;
H = height of column in feet;
f = safety factor;
L = column load in pounds;
A = cross-sectional area of column in square inches;
C = ultimate resistance of concrete in pounds per square inch;
a = total cross-sectional area of the longitudinal reinforcing bars in square inches;
S = elastic limit of the reinforcement in pounds per square inch;
k = cross-sectional area of hooped bar in square inches.

In consequence of the great ductility of hooped concrete and its efficiency in resisting impact, Considère suggests that a factor of safety of 2 to 2.5 may be used. A further advantage of hooped concrete columns over columns which have mainly longitudinal reinforcing bars is, that it does away with the delicate work of getting comparatively heavy longitudinal bars truly central and plumb.

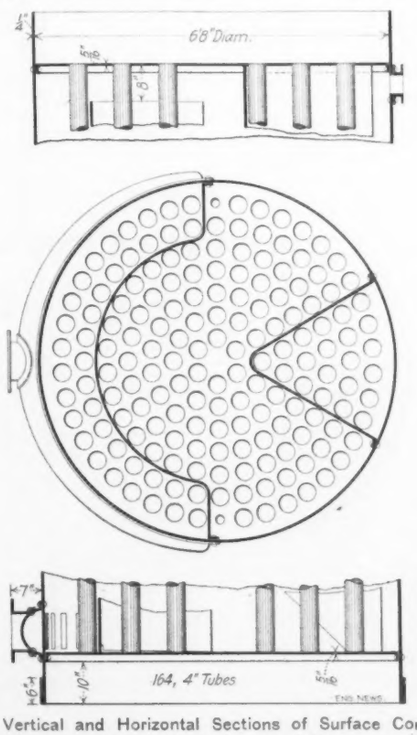
With the Ingalls skyscraper, which is being erected in Cincinnati, O., of steel-concrete, columns having as many as eight round steel rods about 3 ins. in diameter for longitudinal reinforcement have been used; and much time and labor have been consumed in getting these rods properly placed and plumbed. With hooped concrete columns, this difficulty disappears; and, moreover, a better and more ductile column is obtained.

S. D. Bleich.

Mitchell Building, Cincinnati, O., March 14, 1903.

A SURFACE CONDENSER USING MOIST AIR AS THE COOLING MEDIUM.

In our issue of Dec. 25 last we illustrated a surface condenser using moist air as the cooling medium, in which a large number of very small



Vertical and Horizontal Sections of Surface Condenser Using Saturated Air.

Arthur Pennel, Kansas City, Mo., Inventor.

tubes were used to obtain the necessary heating surface, and a fan-blower was used to force air through the tubes. We show herewith another apparatus also using moist air for cooling, but dispensing with the fan and using natural draft to produce the flow of air through the tubes. Sectional views of the apparatus are shown in the accompanying cut.

The apparatus consists of a cylindrical shell, containing as many 4-in. steel tubes as can be conveniently inserted, carried on supports which stand on the curb wall of a cistern. The shell is continued upwards to form a flue and increase the draft.

A centrifugal pump circulates about one-half gallon of water per horse-power per minute from the cistern below the condenser up over the upper tube plate. By a simple device this water is caused, when descending the tubes, to form a film over their entire interior surface.

The circulating water falls into the cistern below, to be again taken up by the circulating pump. The water level in the cistern is kept constant by a float governing a valve on the supply pipe.

The current of exhaust steam entering at the side of the shell is caused by suitable baffle plates to circulate among the tubes, condensing as it goes. The condensed water is led from the bottom tube plate by a pipe, connecting with the suction pipe of the vacuum pump, to the hot well.

The condensing action is as follows: The exhaust steam in the shell heats the tubes and the water film on their internal surface, the latter evaporates, at the expense of the latent heat of the steam, into the air in the tubes, saturating the air at its own temperature.

Hot saturated air is much lighter than the normal atmosphere, so an upward current ensues, the hot vapor-laden air rushing up the flue and carrying off the heat into the atmosphere, while fresh air enters from below to replace it and be saturated at a higher temperature in its turn.

An excellent feature of this device is that the film of water on the cooling surface is secured without interference with the ascending air currents and also without the use of sprays through small orifices, likely to become clogged with rust or sediment. These two features are rocks on which many designers of cooling towers have split.

Two condensers of the type above described were erected early in 1898 at No. 3 Power House of the Armour Packing Co., in Kansas City, Mo.

Tests of a condenser of this type made in April, 1901, showed the average amount of steam condensed per square foot of cooling surface per hour to be 2,038 lbs. The air entering the condenser had a temperature of 62° and it left at a temperature of 106°. The following below gives the principal figures of the test. The condenser took the steam from a 30 × 58 × 48-in. engine running at 45 r. p. m. The trial lasted nine hours:

Average steam pressure at engine by gage..	139.8	lbs.
" vacuum per engine gage.....	18.38	ins.
" vacuum per mercury column.....	17.50	ins.
" temperature in condenser	123.7°	F.
" " of circulating water..	116.4°	F.
" " of city water	52°	F.
" " of outside air	62°	F.
" " saturated air, cond's'r	106°	F.
" draft in stack of condenser.....	1-10-in.	
" humidity of outside air.....	67%	
Total amount of steam condensed.....	71,550	lbs.
Average amount of steam condensed per min.	132.5	"
Average amount of steam condensed per hour	7,950	"
Total amount of circulating water used.....	1,032,060	"
Average amount used per minute.....	1,911.22	"
Total amount of city water used.....	31,150	"
Average amount used per minute.....	57.7	"
Ratio of circulati'g water & steam condensed	1 to 14.42	
Ratio of city water and steam condensed....	1 to 0.435	
Average horse-power of engine during trial, per indicator cards	569.74	
" hourly weight of steam used, per I. HP.	13.95	lbs.
" HP. required to run air pumps...	10½	HP.
" HP. to run circulating pump.....	3	HP.
Total amount of condensing surface.....	3,900	sq. ft.
Amount of steam condensed per sq. ft. surface, per hour	2.038	lbs.

We are indebted for the above information to Mr. Arthur Pennell, 1315 W. Eighth St., Kansas City, Mo., the inventor of the above-described condenser.

PASSENGER TRAFFIC ACROSS THE ATLANTIC in the first and second cabins appears to be about stationary, according to a recently published table. The total number of cabin passengers landed in New York by transatlantic lines reached 150,028 in 1891, and has not since attained so high a figure. During the years from 1894 to 1898, inclusive, the arrivals of cabin passengers were below 100,000, and fell to 80,586 in 1898. Since 1899 the arrivals have been in excess of 100,000, and reached 139,848 in 1902. The steerage passengers arriving at New York in 1902 numbered 574,276. The highest previous record was 445,290 in 1891.

LOCAL COAL POCKETS FOR THE LEHIGH VALLEY R. R., AT NEWARK, N. J.

By Walter G. Berg,* M. Am. Soc. C. E.

The Lehigh Valley R. R. Co., finding itself in the position of either having to renew the old coal pockets at Broad St., in the city of Newark, N. J., or building new ones, came to the conclusion that it would be advisable to construct new pockets with modern improvements. The new structure, located at the corner of Pennsylvania Ave. and Poinier St., was placed in operation in November, 1902, and has proved very successful. The essential elements of the design are a gravity feed for loaded cars from the storage yard to the foot of an inclined plane, up which cars are handled by cable to the top of the pockets. The cars then drop entirely by gravity the length of the pockets and thence by a gravity switchback into the return track for empty cars.

The most noteworthy features of the design consist of the successful selection of the various track gradients and the excellent provision made for screening the coal as it leaves the pocket and for the rescreening of the screenings so as to separate automatically the small sizes of coal from the dust.

The track layout is more or less affected by the shape of the property available. Capacities of the various yards are: for loaded cars, 72 cars; for empty cars, 148 cars; and also surplus standing room when necessary for 58 additional cars. In addition, there is track delivery room for 46 cars. All cars are figured as 36 ft. in length.

A system of gravity approach tracks for loaded cars is located at the south end of the structure. In this yard cars are placed by the yard engine, as previously designated by the agent, on the five tracks, so that shifting is not necessary on the gravity tracks. The loaded cars are dropped down by gravity to the foot of the incline over the depressed "Barney" or "Dummy" pit, and at a given signal the "Barney" is brought up back of the cars and finds its bearing on the buffers of the cars.

The choice of a "Barney" system in place of an endless tail rope system was caused by the fact that the service required is intermittent and comparatively small, as a maximum not over 100 cars per day, and hence speed of operation is not so important as safety.

At the head of the incline the cars are switched by gravity to either side of the structure and are stopped over the desired pocket or bin, where they are discharged. When empty they are run by gravity out on the tail track and return automatically over the three-way switch (which always stands set for the return track) down the return track in the center of the structure and out into the yard for empty cars, where the trains of empty cars are formed for the road engines to haul away without additional switching being necessary.

The structure proper is 784 ft. long by 51½ ft. wide, covering an area of 45,000 sq. ft. The total length of trestling from barney pit to end of tail track is 1,265 ft. The entire layout, including yard and team delivery tracks and roadways, covers an area of 130 ft. in width and an average length of 2,180 ft., or a total area of 6½ acres.

The foundations of the structure are concrete piers, a portion of which are supported on piles which are cut off at the water line. The piers are carried up to a point about 18 ins. above the ground level. On top of these piers the frame structure is started, being composed of yellow pine and white oak. The shed is built of hemlock, excepting the larger timbers, which are of yellow pine.

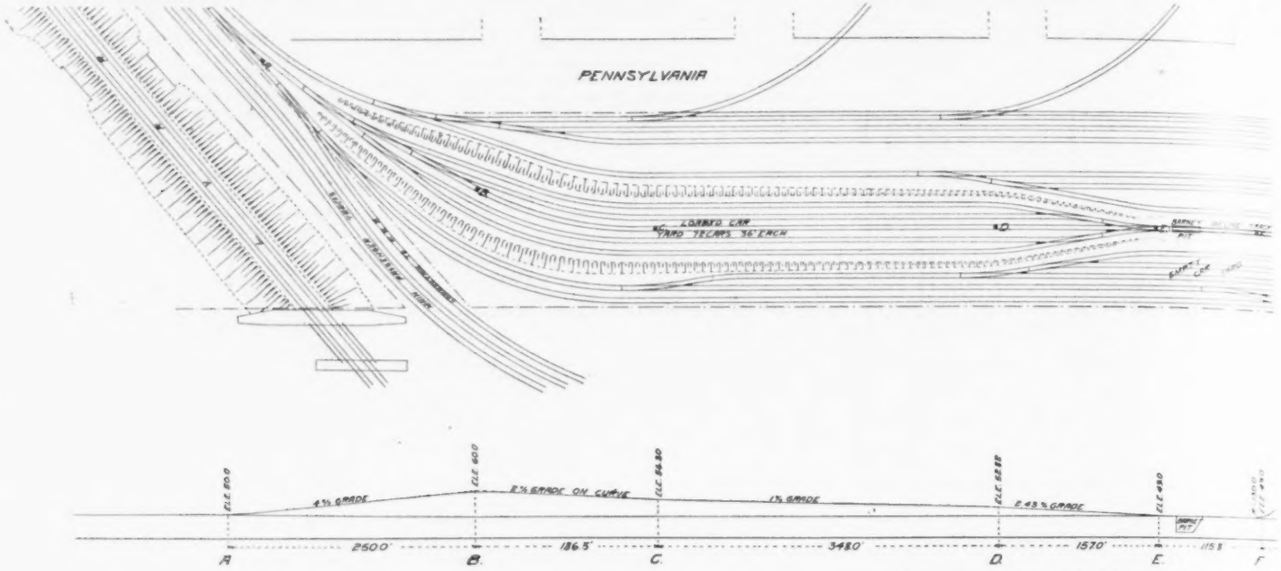


FIG. 1. PLAN OF NEW COAL POCKETS AND
Walter G. Berg, M. Am.

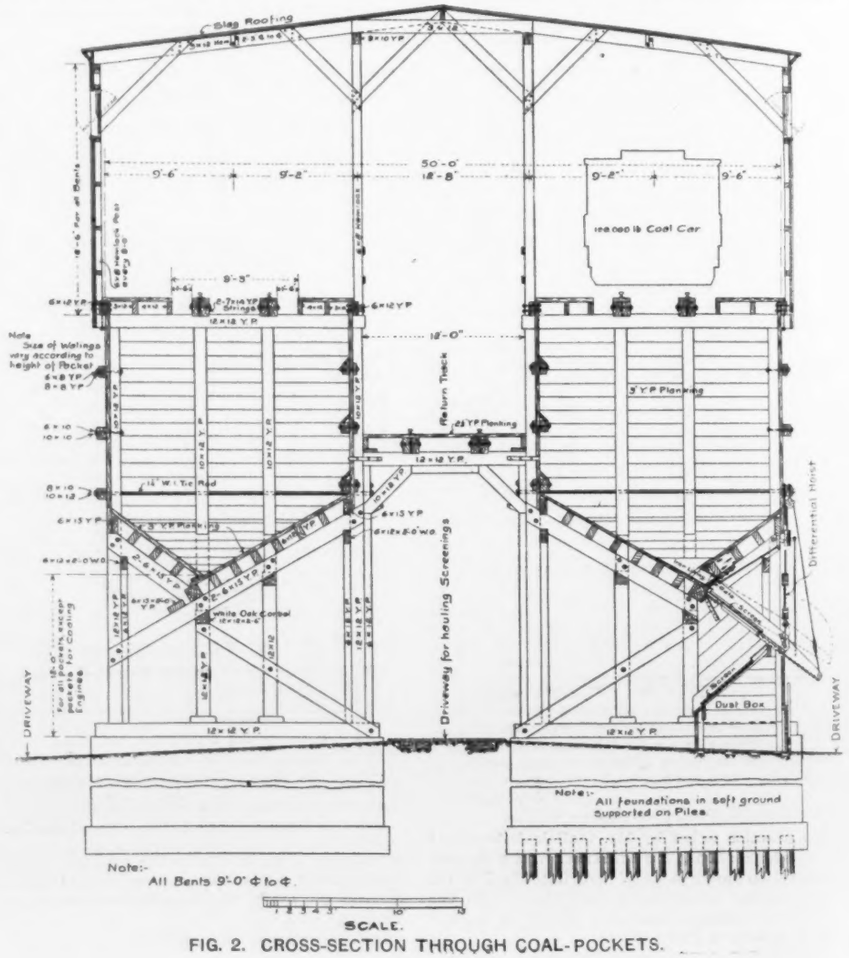


FIG. 2. CROSS-SECTION THROUGH COAL-POCKETS.

*Chief Engineer, Lehigh Valley R. R., 26 Cortlandt St., New York City.

The delivery of coal to wagons is done on the two sides of the structure, with dust boxes along the outer face and ample space for the small screened coal back of the dust boxes. A driveway for carts is provided under the structure below the return track, for the collection of screenings. Shoveling in the main pockets is not necessary, as the bin bottoms are properly hoppered. There are two cross roadways under the pockets for the use of teams. On top of the pockets is a shed (which covers the storage portion of the structure), having a slag roof with built-up gutters and leaders discharging at surface of driveways.

There are 150 pockets with individual outlets for delivery to wagons and three pockets for engine coaling. The pockets for wagon delivery have a capacity from 55 tons to 80 tons, varying according to their position.

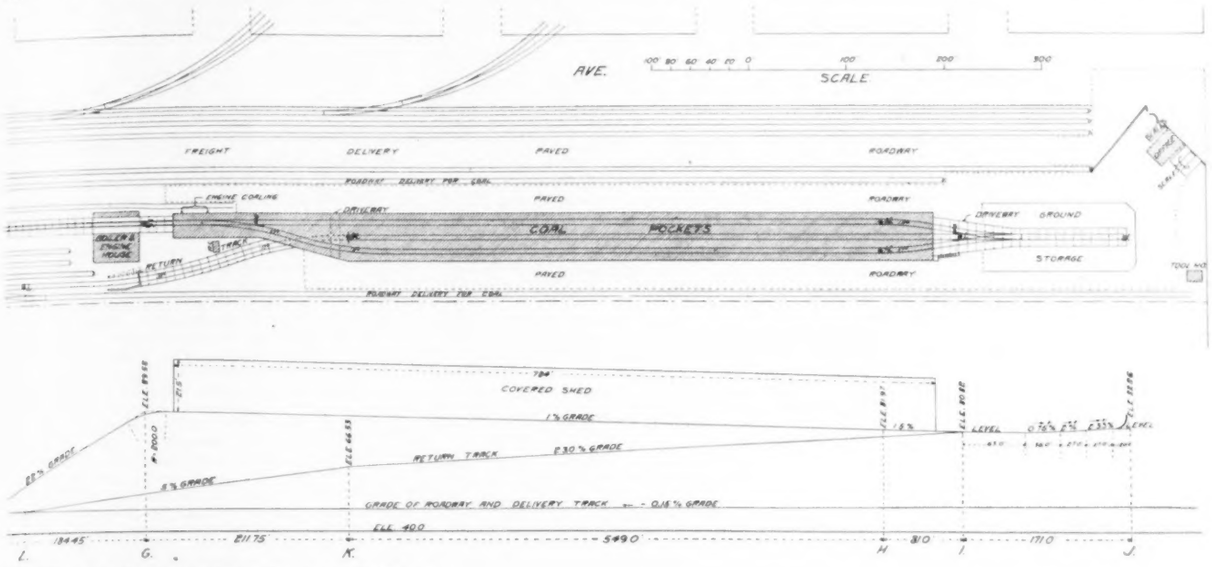
The storage capacity of pockets is 10,500 tons without trimming, and an additional capacity of 1,500 tons if pockets are trimmed. There is a ground storage (used for small sizes) at the north end under the tail track trestle with a capacity of 4,000 tons, making a total storage capacity of 16,000 tons of 2,000 lbs.

Coal is handled, after being delivered to the individual pockets, by the drivers of the carts, who open the iron gate at the bottom of pockets by pushing up on the lever, it being thought best to have the positive action or down pull on the lever to close the gates, i. e., retard the flow of coal. The opening of the gate allows the coal to flow over a wire screen, which is set in a movable box, or body, hinged at one end and operated at the other with a differential hoist. This is an essential improvement in this plant over the usual form of fixed screens. Extensive experiments with different sizes of coal and under varying conditions indicated that one fixed angle would not give proper results, and that it is necessary to provide a quick working adjustment in angle of the screen for the varying conditions of the service. The coal passing over this screen is delivered direct to the wagons over swinging aprons. The screenings passing through this screen fall upon a second fixed wire screen, which in turn screens the dust from the small sizes, the small sizes of coal falling towards the interior passageway, and the dust dropping into the dust boxes immediately under screen with a gate at the front of the box to allow the dust to be shoveled out at the level of the outside roadway.

The roadways around the pockets are paved with Belgian stone blocks and lead to the office situated at the corner of Pennsylvania Ave. and Poinier St. Ample space is allowed around the office and pockets for both empty and loaded wagons.

At the office there are three wagon scales, two 15-ton capacity suspended scales, and one 10-ton capacity platform scale. All the scale platforms are 9 ft. by 22 ft., the extra length being caused by the desire to weigh the horses with the wagons.

The engine and boiler house is built of brick and made fireproof with concrete floors, wired glass and metal frame windows, metal-covered doors and concrete roof covered with slag roofing. The hoisting engine is a horizontal 20 × 30-in. double cylinder reversible link motion engine, having a minimum delivering capacity of 20 cars of 100,000 lbs. capacity per hour. The main drum is 8 ft. in diameter, and the hoisting rope is 1¾-in. diameter "Leschen's" patent flattened-strand cru-



YARDS OF LEHIGH VALLEY R. R. AT NEWARK, N. J.
Soc. C. E., Chief Engineer.

FIG. 3. VIEW OF INCLINE TRACK AT END OF COAL POCKET.

cible-steel rope. The engine has an auxiliary drum and steel rope of ⅝-in. diameter for a tail rope, used to start the "Barney" back at the top of incline.

The boilers are two 150-HP. return tube horizontal type in brick setting, with steel stack 75 ft. high. Coal is delivered on the floor of the boiler

room from a bin which is filled from the incline track.

The pockets have a fire protection system consisting of a series of hydrants sunk below the surface of the roadways and operated at the surface of the ground or from the upper floor of pockets under the shed. There are also hose carts and fixed hose reels at various points.

The work was designed and built under the direction of the writer, assisted by E. D. B. Brown, architect; J. G. Hocke, Division Engineer; and E. F. Ackerman, Assistant Engineer.

The contractors were: for the structure, Messrs. Geo. W. Rogers & Co., 44 Broadway, New York city; hoisting machinery and boilers, The Exeter Machine Works, Pittston, Pa.; Earle C. Bacon, Engineer, 26 Cortlandt St., New York city; paving, Holmes & Cogan, Jersey City, N. J.

NOTES ON CEMENT AND CONCRETE CONSTRUCTION IN THE U. S. GOVERNMENT FORTIFICATION WORK FOR 1902.

The report of the Chief of Engineers U. S. A. for 1902 contains a number of interesting studies concerning the use of cement and concrete in the fortification work now in progress along the Atlantic and Pacific coasts. These works of course require concrete work of an unusually solid and durable character and the large amounts of concrete used also warrants quite elaborate plant for its manufacture and necessitates rigid supervision of all the details that contribute toward improving its quality and reducing its cost. The purpose of the work in many instances necessitates also that the concrete be made impermeable to water either by special treatment or by waterproof coatings or constructions and much study has been devoted to this important feature. Many of the devices and methods adopted by the army engineers in meeting these requirements of their work are susceptible of application in concrete work in civil practice and we give them in some detail in the following paragraphs:

Tests to Show Suitability of Various Kinds of Sand for Use in Concrete.

By Capt. Harry Taylor, Engineer Corps, U. S. A.

The most important information obtained during the year relates to the availability of crusher dust as a substitute for sand in mortar. The strength of briquettes made with standard crushed quartz, a commercial sand much used in concrete in this vicinity, which is taken from a beach near the mouth of the Merrimac River, Massachusetts, and known as Plum Island sand, and crusher dust was tested and compared. A total of 2,940 briquettes were made in the proportions of 1 to 3, 1 to 4, and 1 to 5. Of these, 1,650 have been tested and the results recorded, the averages being shown in Table I.

From the above tables it is seen that the tensile strength of the briquettes made from crusher dust is greatly superior to that of the briquettes made from cemmercial sand or standard crushed quartz.

In order to eliminate as far as practicable any inequality or irregularity due to the cement, six different brands of cement were used in the above tests, an equal number of briquettes of each brand being made.

In order to secure uniformity in measurement of volume of the several sands, the comparative specific gravity of the loose sand was first carefully determined, and thereafter volume measurements were determined by weight, No. 1 being used as standard. During the entire period of manipulation up to the time of tempering the mortar the sand was kept thoroughly dry by heating. Briquettes were formed by machine hammer. Each batch of mortar was mixed by hand for three minutes after adding the water, which was fresh, of 60° to 65° F. temperature, and was all added to the dry mixture at one time.

As soon as made, briquettes were placed in a moist closet, where they were kept for 24 hours. They were then placed in fresh water, the temperature of which fluctuated between 60° and 70° F.

Two series of tests were made. The mortar of the first series contained the greatest quantity of mixing water that it would hold during the process of forming into briquettes without running from the mold; the second series contained such quantity as would cause a slight flow to take place.

The fineness of the sands used was also determined. The percentage retained on the various sieves is shown in Table II.

To this table has been added the result obtained from sifting a sample of sand from that recently delivered, which also came from the mouth of the Merrimac River, and which is shown in this table as No. 4.

The percentage of volds given in the above table is of the dry, loose sand. To obtain these values the sand was given a uniform drop of 9 ins. into a cylindrical graduate, care being taken not to cause settlement by shock. Water was then poured into the graduate until it rose to the height occupied by the sand in the graduate before settlement caused by the added water took place. The quantity of water thus used represented the total of the volds. The question arose: Does the percentage of voids in sand obtained by this method represent the proper percentage of voids? In my opinion it does not, for the reason that when sand is used in mortar it is used with water and not in a dry state; it is used compactly, not in a loose state. In order to ascertain what the effect would be by compacting the sand and adding water, the experiment of wetting and compacting the sand was tried.

TABLE I.—Showing Tensile Strength of Mortar Made With Various Kinds of Sand.
(First Series of Tests.)

No. of sand.	No. of briquettes broken	Proportions by volume: 1 to 3 age					1 to 4 age					1 to 5 age					
	each period.	24 hrs.	7 days.	1 mo.	3 mos.	6 mos.	1 year.	24 hrs.	7 days.	1 mo.	3 mos.	6 mos.	1 year.	24 hrs.	7 days.	1 mo.	3 mos.	6 mos.	1 year.
1	14	103	370	397	376	381	355	53	243	282	266	259	227	31	187	221	211	190	161
2	36	105	241	274	294	290	291	65	169	198	207	192	185	36	132	155	159	145	144
3	12	79	397	544	607	628	602	37	267	395	494	512	484	25	211	336	428	431	416
(Second Series of Tests.)																			
1	12	62	302	425	449	436	...	17	153	283	329	325	...	9	103	189	244	222	...
2	12	58	224	289	310	310	...	23	136	193	220	234	...	7	85	130	168	154	...
3	12	111	390	505	603	593	...	00	287	411	453	501	...	34	212	322	377	425	...

Note.—No. 1, standard crushed quartz; No. 2, Plum Island sand; No. 3, crusher dust.

This reduced the percentage of voids in the No. 1 sand to 42%, in the No. 2 to 32%, and in the No. 3 to 28%. As would be expected, crusher dust which contains all sizes of particles, from the coarsest to the finest, when compacted shows the smallest percentage of voids. It seems that this may be at least a partial explanation of the higher tensile strength of the briquette made from crusher dust. The cement having in the crusher dust a smaller percentage of voids to fill makes the resulting mortar a more compact mass than with either of the other sands. The individual particles of the crusher dust are just as sharp and angular as the particles of the standard sand, which is not true for the particles of the river sand, these being somewhat rounded by the action of the water. The deduction is that a sand which may show the highest tensile strength for any proportion of cement may not necessarily make the most compact concrete.

Acting on the information gained by the tests outlined above, crusher dust was used in place of sand in the concrete made in this harbor (Boston, Mass.) during the summer of 1901. A most excellent concrete was produced, using proportions of 1 cement, 5 crusher dust, and approximately 11 broken rock. The concrete was mixed very wet, and the proportion of rock was so regulated that the mortar would not flush above it. This left the top surface of each layer very rough, small particles of broken rock sticking up above the mortar. When the next layer of concrete was added it bonded perfectly to the layer below, making a monolithic mass.

This summer the supply of crusher dust was very low, and the price bid for it was so high as to make its use prohibitive and contract was accordingly made for Merrimac River sand. The size of the sand is given in the last table above as sand No. 4. In appearance in the pile this sand is an ideal sand for concrete. It is almost entirely quartz, coarse and perfectly clean. Practically, in making concrete it is an exceedingly poor sand. In order to produce a passably decent concrete it has been necessary to increase the amount of cement to the proportion of 1 cement to 3 sand. Even this proportion of cement does not make a concrete which compares with the 1 to 5 crusher dust as regards its compactness.

If crusher dust is such an excellent material to use for making concrete, the question may be asked: Why should broken stone be screened at all, or, in other words, why should not crusher dust be left in with the crushed stone? The answer to this is, that the proportion of crusher dust in any part of the crushed stone cannot be known accurately. In the pile of crushed stone the dust gradually settles to the bottom; the larger pieces of the broken stone roll down the slopes and are used separately. As the bottom of the pile is reached the finer stone and a larger proportion of the crusher dust are found. Were it not for this fact, it would be a decided advantage in obtaining compact concrete to take the crusher stone as it comes from the mixer, including the dust and all sizes of the broken stone from the smallest to the largest.

Damp Proofing for Ceilings of Gun Emplacements.

By Maj. Geo. W. Goethals, Engineer Corps, U. S. A.

In the construction of the 12-in., 10-in., and 6-in. gun emplacements, carried on during the fiscal year, special efforts are being made to prevent percolation of water and to reduce condensation to a minimum. Batteries previously constructed in this locality, and which were practically dry for some time following their completion, have, in time, gradually developed cracks in the concrete masses so as to permit water to pass down through into the rooms, these cracks evidently increasing, judging from the results, as time passed. Portland cement is being used throughout in all constructions and concrete is being mixed very wet. The use of asphalt has been abandoned, and lead and asbestos felt have been substituted in the waterproofing courses. The ceilings of all the rooms are to be constructed of concrete with twisted steel rods. In making the mortar for the ceiling a mixture of alum and soap is added to the concrete. When of sufficient height and proper grade a coating of roofing paint is applied, over which is placed lead for the magazines, and three layers of asbestos felt, laid as shingles are laid, for all the other rooms. This is again coated with roofing paint and then covered with a layer not to exceed 1½ ins. in thickness, of poor mortar in the proportion of 1 of cement to 6 of sand, above which is placed the ordinary concrete mixed 1:3:6 up to the platform level of the parapet. It is expected that any cracks that may develop in the upper surfaces will not possibly extend below the lead or felt, so that percolation will be impossible.

Damp Proofing Sunken Magazines and Rooms.

By Col. Peter C. Hains, Engineer Corps, U. S. A.

To demonstrate the permeability of concrete an experiment was made at the 12-in. gun magazine at Fort Armistead, near Baltimore, Md. A trench 4 ft. wide, 4 ft. deep and 30 ft. long was dug in the earth parapet at the edge of the concrete in front of this magazine, as shown by Fig. 1. This trench was filled with water and on the second day water commenced dripping from the roof of the powder magazine and shortly after from both rooms, running down the side walls. There had been no rain for a month, and the magazines, before the water was put into the trench, were comparatively dry. This showed conclusively that there was less resistance to the passage of water through the 30 ft. of concrete than to its passage through the sandy material forming the earthen portion of the parapet. To shut off the water from these rooms and from the similar rooms of Fort Howard and Battery Strieker inside metal ceilings were built which drained to the air spaces at the sides of the rooms.

Stoppage of Leaks in Concrete with Linseed Oil.

By Capt. Eugene W. Van C. Lucas, Engineer Corps, U. S. A.

From the beginning of the fortification work at Fort Caswell, North Carolina, it has been found almost impossible, with the unstable subsoil, to prevent unequal settlement and consequent cracking in the concrete, and various devices have been tried in the effort to stop such leaks. To Assistant Engineer S. F. Burbank, in local charge, is due the credit for the successful application of the oil treatment, which has resulted in an apparently complete solution of this difficulty. It was noticed that water falling on concrete surfaces near the guns, which had been coated with oil used on the guns, would not absorb the moisture. This led to a coating of the entire concrete mass with the boiled linseed oil. Where large cracks occur they are filled with cement grout, and the linseed oil is poured in as long as it is absorbed. There is formed in the crack a gum from the oil which ultimately fills it to the top, after which the entire surface is coated with successive applications of the oil until it ceases to be absorbed.

Previous to the trial of this method the two 12-in. emplacements were notably leaky, and for the purpose of experiment the worst of the two was selected and treated as above outlined, with the result that it was made per-

TABLE II.—Showing Fineness of Sand Used in Mortar Tests of Table I.

Sand No.	Retained on sieve No. 4	12	20	30	50	80	100	Passed through No. 100.	Loss.	Total.	Specific gravity Dry—loose.	Volds.
1	..	..	..	100	..	..	..	..	..	100	1.225	50%
2	..	0.8	9.9	44.9	39.1	4.8	0.5	..	..	100	1.481	32%
3	..	6.5	5	12	21	21.5	9	23.5	1.5	100	1.366	47%
4	..	13.9	24.5	51	10.2	.2	.1	.1	..	100	....	..

tightly water tight. Since then all of the emplacements of the post have been treated in the same manner and may now be considered perfectly water-tight.

It is probable that it will be necessary to give a coating of oil, at least near cracks, when the concrete mass expands and contracts in the spring and autumn, but this will be comparatively inexpensive and take very little time. One very gratifying result of this oil treatment is the killing of the glare from the concrete surfaces, which heretofore has been particularly objectionable. The resulting color is a brown, which is restful to the eye and blends with the color of the surrounding sand hills, making the emplacements very difficult of detection from a distance.

Stoppage of Leaks in Concrete with Asphaltum and Oil.

By Maj. Wm. T. Rossell and Capt. Spencer Crosby, Engineer Corps, U. S. A.

This battery was begun in 1895, was practically completed in 1898, and was the first modern battery built in the Mobile (Alabama) district. While none of the later constructions has ever given any trouble worth mentioning from leakage, some rooms in this older battery have been persistent offenders in that respect. Efforts from time to time have been made to stop the leaks, but with only partial success. Washes of soap and alum were applied alternately to exterior surfaces. Subsequently hot linseed oil was tried, the larger fissures being first filled with asphalt. During the past fiscal year warm linseed oil, to which 25% of naphtha had been added, was applied to the surfaces, while at the seams and cracks grooves ⅝-in. in width and from ¾-in. to 1-in. in depth were cut and filled with asphalt. In one or two instances, where a small crack extended down into the concrete for some depth, the crack was first filled with asphalt diluted with petroleum residuum oil, after which the groove was filled with the ordinary asphalt. As a result of the above methods the leakage has been reduced to but a very small percentage of what it was originally, although not entirely stopped.

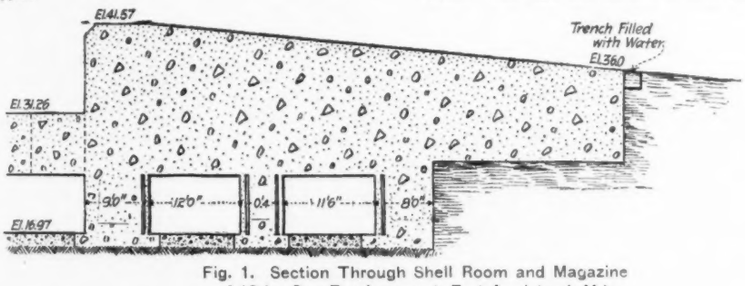


Fig. 1. Section Through Shell Room and Magazine of 12-in. Gun Emplacement, Fort Armistead, Md.

A Sliding Rupture Caused by Tarred Paper Waterproofing.

By Maj. Wm. T. Rossell and Capt. Spencer Crosby, Corps of Engineers, U. S. A.

The mortar battery at Mobile, Ala., consists of two pits, open to the rear, with a central traverse between them and a traverse on each flank. To prevent leakage into the magazines and rooms in the traverses the following method of waterproofing was applied to the top surface of the concrete covering:

This surface was given a slope of 1 on 21 or 22, and, after being troweled smooth, was allowed to dry thoroughly before the waterproof coat of tarred paper and asphalt was applied. The paper used was ordinary tarred building felt 32 ins. wide, received in rolls weighing about 50 lbs. each. It was cut into lengths as long as could be conveniently used, generally about 20 ft. The asphalt was stated by the manufacturers to be made from Trinidad asphalt and pulverized limestone and to contain about 25% of bitumen. The mixture was brought to standard consistency in the process of manufacture. For use on the work it was heated in an asphalt kettle, having a capacity of one barrel, to a temperature varying from 300° to 350° F. The kettle was placed in the immediate vicinity of the work and the hot asphalt was carried in buckets as needed.

It was first applied with ordinary asphalt mops to the top of the concrete along the foot of the slope over a distance equal to the width of the paper, and the latter was then laid as speedily as possible. A thin layer of asphalt was immediately applied to the top of the paper, lapping up the concrete slope a short distance, and another layer of paper was then placed as before. This operation was continued up the slope somewhat in the manner of shingling, about 7½ ins. of each layer of paper being exposed. This gave usually a thickness of four layers of paper with thin layers of asphalt in between at all points of the slope. After the surface to be waterproofed had all been covered in this manner a final coat of asphalt was applied, the thickness of the waterproofing when completed varied somewhat, but was usually between ¼-in. and ⅜-in.

Along the toe of the slope was a concrete cornice with a depression forming a gutter along its inner edge. A layer of concrete, made in the proportions of 1 of cement, 2 of sand, and 4 of gravel, was placed over the waterproofing, its thickness at the top of the slope was about 2 ins. and at the foot near the cornice about 4 ins. On top of the concrete layer the sand covering was placed, having a thickness of 17 ft. at the highest point. Fig. 2 is a section through the cornice showing the construction described.

The above method of waterproofing has been absolutely successful as far as preventing leakage is concerned, but on July 3, 1901, a few months after the completion of the mortar battery, the covering of the west flank traverse slid bodily into the pit. Upon examination it was found that the concrete cornice along the whole face of the wall had given way and the thin layer of concrete, carrying with it the sand covering, had slid down the smooth slope presented by the waterproofing. Though the slope was very gentle, only 1 on 21 or 22, yet the tarred paper and asphalt was evidently such a good lubricant that the pressure of the sand, acting through the concrete layer overlaying the waterproofing, had been sufficient to break down the cornice.

Asphaltum and Alum and Lye Waterproofing; Defenses of the Mouth of Columbia River.

By Capt. William C. Langfitt, Corps of Engineers, U. S. A.

The following method is used with success in waterproofing the foundation and the walls: Supposing the concrete foundation and floor to be 1 ft. thick, put in the first layer of concrete about 6 ins. thick, and plaster it with a mortar of .1 of cement and 4 of sand, leaving it rough under the wooden float. When this coat of plaster is thoroughly dry, cover it with two coats of Trinidad asphalt cement applied hot, at a temperature of about 280° F. If the conditions are particularly bad, and the keeping out of the water considered difficult, sheets of asbestos felt may be embedded between layers of asphalt. The asphalted surface is then plastered with a mortar consisting of 1 of cement to 4 of sand, the concrete placed in the wet mortar, and the floor completed. If water is to be kept out of the walls also, these are plastered on the outside with a 1 to 3 mortar and covered with two coats of Trinidad asphalt cement, as before, being sure to make a continuous and waterproof connection between the floor and wall asphalt courses. If the work is carefully done, the floors and walls should be perfectly waterproof. The use of coal tar as an admixture to the asphalt is not considered advisable for underground work, as the coal tar is susceptible to injury from the continuous action of the water.

Where conditions were not bad and there was no danger of damp or wet floors from water through the foundations, no asphalt course was put in, but the walls down to the footings were plastered with 1 of cement to 2 of sand mortar, left rough under the wooden float and coated with two applications of the alum and lye waterproof wash.

For asphalt course over magazines or other rooms or galleries between two layers of concrete, the I-beams were covered with concrete not less than 6 ins. thick as a minimum at the air spaces or at the down spouts of the valleys. This concrete was then plastered with a mortar of 1 of cement to 4 of sand, leaving it rough under the wooden float, and, when thoroughly dry, and on a dry, warm day the asphalt was applied. The first method employed was to give the plastered surface one coat of ordinary Trinidad asphalt cement at a temperature of about 280° F., and about 1-16-in. thick. Upon this was spread a binder of granolithic rock heated and mixed in the kettle with the asphalt cement to about 250° F., and the mixture well stirred to insure a thorough coating of the small rock. This binder was then spread on the asphalt coat first applied to a thickness of about ⅝-in., and the binder finished off with a top coat of the asphalt cement, similar to the first coat. This kind of asphalt course was applied only to one emplacement. In all other works simply two coats of Trinidad asphalt cement, heated to 280° F., were applied to the plastered concrete surface.

In both methods the asphalt surface was plastered with a 1 to 4 mortar about ½-in. thick, and the concreting immediately proceeded with. Both kinds of asphalt courses have been satisfactory, but the former is more expensive to apply and not considered superior to the latter. In completing an asphalt course between two layers of concrete, at rear or face wall of the emplacement, the asphalt was carried to the surface and turned down, or stopped within a few inches of the face and turned up into the concrete. In the former instance the asphalt exudes and runs down the wall, making unsightly streaks of black. The second method was employed where the rear of the loading platform was provided with a coping. Here the asphalt was turned up under the coping, preventing exudation of the asphalt and leaving no distinct joint between the two layers of concrete. Where it is not practicable to turn the asphalt course up into the concrete at the face wall, it is thought that it would be entirely successful to have the plastered surface waterproofed with the alum-and-lye preparation about 1 ft. back from the face wall and then end the asphalt course within a few inches of the face of the wall. This would prevent any possible overhead water percolating through the waterproofed plaster and at the same time do away with the separation joint in the concrete and the exudation of the asphalt.

The alum-and-lye waterproof wash referred to was mixed in the following proportion: One pound of concentrated lye and 5 lbs. of alum to 2 gallons of water, care being taken that every particle is dissolved. This constitutes the "stock," and may be mixed in any quantity. To 1 pint of the "stock" add 10 lbs. of cement, thinning out with water until the mixture spreads easily and well on the walls with a kalsomine brush, filling all the pores in the plaster. This is satisfactorily done when it lathers freely under the brush. Usually 1 pint of "stock" was put into a 12-quart bucket and 10 lbs. of cement stirred in, with enough water added to well fill the bucket.

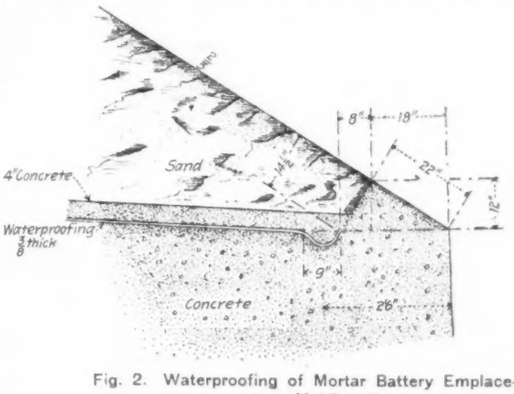


Fig. 2. Waterproofing of Mortar Battery Emplacement at Mobile, Ala.

Much depends, however, upon the condition of the surfaces to be coated, as to dryness. If they are too dry, wet them down with a brush ahead of the waterproofing, the object being to apply the wash as thin as practicable without running, rubbing the wash well into the plaster with the brush. The wash should be applied to the plastered surfaces as soon after the plaster has set as possible, but never when the walls are too warm or when the sun is shining too strongly. Too rapid evaporation of the wash will leave the cement without the necessary moisture to set up, causing it to peel or crumble. It should never be put on too thick or it will scale, nor when the walls and concrete are filled with water and frosty weather is probable. It will not adhere well to old work. This wash is used only on plastered surfaces and gives the best results when applied to them within ten days after the plastering has been done, and the second coat at any time after the first coat has become well set. More than two coats have never been considered necessary. More concentrated lye than specified should never be used, as it prevents the crystallization of the cement, and allows the wash to peel off. Applying the wash with too much lye, or on too dry and warm surfaces, or permitting the sun to shine on it before it has had time to set up, are no doubt the causes of reported failure of the wash.

REMARKS.—The alum-and-lye waterproof preparation has been found to be strictly waterproof, and at no time has there been the slightest trace of leaks through a surface coated with it, provided the concrete remained free from cracks. At Fort Stevens, where most of the parapet sand fills were sluiced in place, water stood for days next to the concrete surfaces under 10 or 12-ft. head, but none ever seeped through the waterproofing. It has been equally effective against clayey soils. In addition to its waterproofing properties, it prevents fungus growth on, or discoloration of, surfaces coated with it. It thoroughly closes the pores of the plaster, prevents dampness, and insures dry walls free from moisture. It has been used on all works since the inception of fortification work in this district, including mining casemates, cable tanks, and torpedo storehouse. This latter, with concrete walls only 12 ins. in thickness, exposed to the weather at all times and rains of weeks' duration, is always dry, and is an excellent illustration of the good qualities of this wash.

CONCRETE-STEEL CHIMNEY FOR THE PACIFIC ELECTRIC RY. CO., LOS ANGELES, CAL

By Jas. D. Schuyler, M. Am. Soc. C. E.*

One of the most notable pieces of construction in concrete-steel recently completed, is the high chimney built for the extensive new power station of the Pacific Electric Ry. Co. at Los Angeles, Cal., in July and August, 1902. This company is building a great network of suburban electric roads, centering in Los Angeles, and although the power eo operate the system will ultimately be supplied by a water power plant on Kern River, 130 miles away, the new steam station is required in the interval of construction of the great water power plant.

The plans for building this great chimney of concrete-steel were submitted by Mr. Carl Leonardt, of Los Angeles, Cal., an expert specialist in that line of construction, and their adoption was urged on the ground of the general superiority of reinforced concrete over steel or brick in the matter of stability and strength. The plans were accompanied by a bid which demonstrated that it was also more economical than either brick or steel, and with this strong argument in favor of concrete-steel the contract was awarded to Mr. Leonardt.

The chimney is 180 ft. in height above its base, which is 15 ft. 6 ins. below the level of the ground. The exterior diameter of the chimney above the shoulder where it first assumes a circular form, is 15 ft. 2 ins., the inner diameter being 11 ft. The shoulder aforesaid is 51 ft. above its base, and is immediately above the two flues which enter the chimney from opposite sides.

The accompanying plans, Fig. 1, show clearly the construction of the great stack, and indicate more exactly than words can describe that it consists of two concentric walls, independent of each other from base to top, and separated by an air space of 11 to 16 ins., increasing in width toward the top. The outer shell, above the shoulder, is 9 ins., 6 ins. and 5 ins. thick, respectively, up to the cap, in sections of about equal height, while the inner shell is 5 ins., 4½ ins. and 4 ins. thick, respectively, from bottom to top, in corresponding sections.

The inner shell ends 4 ft. below the cap and is free to elongate by heat independently of the outer shell. By reference to the sections it will be seen that at intervals of 30 ins., measured around the chimney, the air space is contracted for a length of 6 ins., and reduced to a width of 2¼ ins. At every 5 ft. in height this is again reduced to ¾-in. by the introduction of a concrete brick in the wall. In this manner the oscillation of either shell independently of the other is checked, and the outer shell may sway in the wind ¾-in. without bringing pressure upon the inner shell.

The chimney was built under the Ransome system, with a thorough reinforcement of square, cold-twisted steel bars, both vertically and horizontally in each shell. The horizontal reinforcement consists of rings of ¼-in. steel twisted bars, placed at intervals averaging 18 ins. in the inner shell and 24 ins. in the outer. Vertical bars of ¾-in. square steel, twisted, were placed 1 ft. apart in the lower third of the stack above the flues, 2 ft. apart in the middle section, and 4 ft. apart in the top section of the outer shell. In the inner shell ¼-in. bars were used, spaced about 3 ft. apart in the circumference of the work.

The upper 4 ft. above the ornamental cap consists of a shell of concrete but 2 ins. thick, reinforced by a sheet of expanded metal. The decorative cap 7 ft. high consists of 28 blocks, molded on the ground and hoisted to position. As shown by the drawings these blocks are hollow and are formed by a shell of 2 ins. of concrete, with stiffening cross-partitions, all reinforced by ¼-in. twisted steel rods, embedded in the concrete. Each block of the cap weighs 1,250 lbs. and the entire cap was hoisted and set in three days.

ERECTION.—The original design of the chimney contemplated a straight shaft, 15 ft. in diameter throughout from the base up. Subsequent alterations in the plans of the boiler house changing the relative positions of boilers and chimney necessitated the provision of two flue openings on opposite sides, instead of one. The extra opening thus provided would have materially reduced the sectional area of the chimney at this point, and it was deemed necessary to increase the diameter to 18 ft. for a height of 45 ft. above the base. This change in diameter and form made it necessary to build a special mold for that section, which was rendered more difficult by the square projections of the flue openings, extending from the foundation up.

*401 Douglas Block, Los Angeles, Cal.

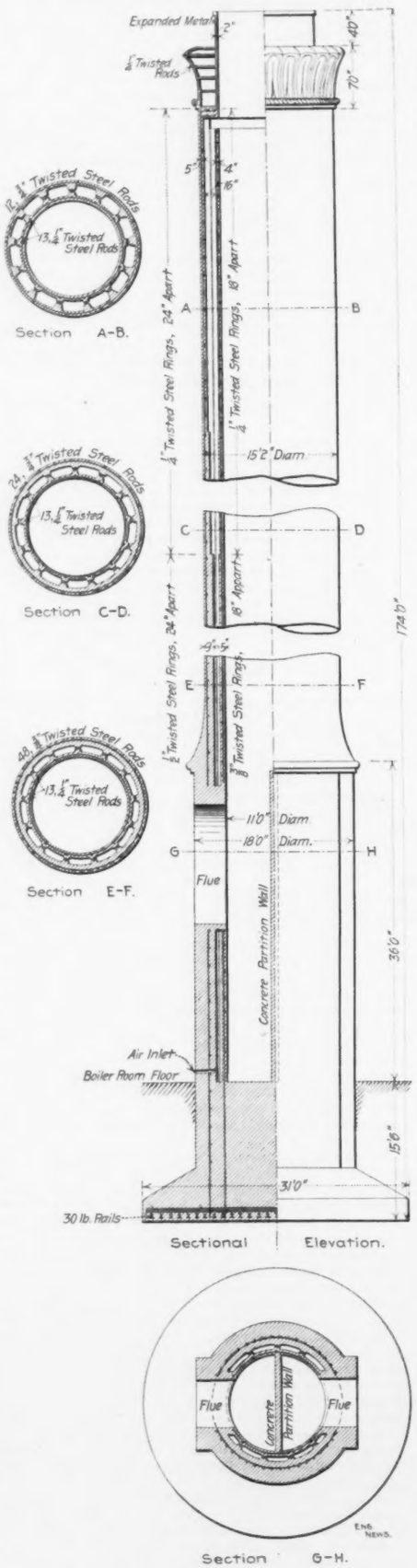


Fig. 1. Details of Concrete-Steel Chimney for the Pacific Electric Ry. Power House at Los Angeles, Cal.
Carl Leonardt, Los Angeles, Cal., Contractor.

By reference to the accompanying drawing, Fig. 2, the turnbuckles by which the mold was clamped together, or loosened when it was to be raised, may be seen. During the time that this base section was being built the mold for the exterior of the circular part had to be pushed up ahead of the work, and supported on the scaffold by which the interior mold was raised, and from which all the work was done. This obviated the necessity of building the 15-ft. mold around the scaffolding 45 ft. up in the air. This inner scaffold was kept ahead of the work all the time, and the exterior molds when loosened, were raised 10 ft. at a time by the suspending screw-rods, and hand wheels, from which they were hung to the head scaffold. The inner mold and cores were raised 5 ft. at each setting, and concrete to the height of 5 ft. was placed each day.

It was customary to place the concrete in the afternoon, and the daily section was completed about 5 p. m. By 9 o'clock next morning the large mold had been hoisted and the lower 2 ft. of its length clamped hard upon the fresh concrete placed 14 hours previously, after which the builders were ready to proceed with the next layer of concrete.

MATERIALS.—The cement used was the California Portland cement, manufactured at Colton, 60 miles east of Los Angeles. The sand was clean, washed, silicious sand from the Los Angeles River bed, and the broken stone used in the inner shell was a special quality of red sandstone from the Sespe district, noted for its hardness and heat resisting qualities. For the outer shell Arroyo Seco crushed granite cobbles were used. The concrete was mixed in a Ransome drum mixer, which always does work thoroughly in concrete mixing. The cement was tested carefully by the contractor, and test blocks of concrete of the proportions used in construction were made daily and tested at regular intervals. The proportions used on the inner shell were 1 of cement to 2 of sand and 4 of broken stone. In the outer shell the proportions were 1:2:6.

The chimney contains approximately 20,000 cu. ft. of concrete, and 850 barrels of cement were used in its construction. The steel embedded in the concrete consists of 10,000 lbs. of twisted bars, and 4,000 lbs. of old rails, which were placed 12 ins. apart, in two layers in the base. The weight of the chimney is approximately 1,430 tons, and the distributed load on its base is less than two tons per square foot. The foundation is laid in a heavy river gravel stratum.

To keep the concrete properly wetted during construction, a circular pipe was suspended from the bottom of the outer mold, and connected with the city water mains. This pipe was perforated with a large number of small holes, and when water was turned on a fine spray completely douched the surface of the chimney. This precaution was not necessary in the interior, where the air was cool and moist.

In the view, Fig. 3, there will be noted a circular swinging platform, suspended below the outer mold. This was seldom used, but was kept close up to the work more as a measure of precaution to catch some workman who might perchance lose his balance and fall.

The exterior of the chimney, Fig. 4, has not been trowelled, plastered, or washed over with cement, but is in the precise condition in which it was left when the molds were removed, and yet it is perfectly plumb, true and smooth, and evidences the extreme care with which the entire construction was carried out.

The plan of the circular molds, Fig. 2, shows their ingenious construction. The hoops are built up of successive layers of ⅜-in. strips of Oregon fir, 4 ins. wide. These were made 5 ins. in thickness, and combine rigidity with enough elasticity to permit the molds to open and close at the one joint on the side, where the motion was con-

trolled by a turnbuckle on each band. These bands were six in number.

METHOD OF WORKING.—The entire construction was carried on from the interior, and all material was hoisted up the shaft by an electric hoist. All the scaffolding was built inside, and consisted of four 4 × 6-in. timbers for uprights, with 2 × 10-in. horizontal braces bolted thereto every 5 ft., and 1 × 6-in. cross-braces. The head, or top, scaffold was formed of 6 × 14-in. timbers, to which the hoisting rods were attached. To obviate the labor of dismantling this head scaffold with each setting of the molds, a telescope scaffold was built inside the main upright scaffold, which enabled the workmen to disconnect the head scaffold, raise the entire read intact and put in extensions to the uprights, all of which could be done in 2½ hours. The work was executed from start to finish without accident or mishap. Six tampers, selected from among the most experienced cement workers of Mr. Leonardt's corps of trained men, were entrusted with the consolidation of the concrete.

Mr. Leonardt is now engaged in building a concrete iron bridge, with a roadway 100 ft. in width, at Santa Monica, and has recently been awarded the contract for a high concrete dam acress McCloud River, by the McCloud River Electrical Power Co.

OTHER CONCRETE-STEEL CHIMNEYS.—In 1898 a chimney was built under the Ransome system at Constable Hook, N. J., for the Pacific Coast Borax Co., of concrete, reinforced with cold twisted rods of square steel. This is 150 ft. in height, 7 ft. inside diameter with an inner and outer shell. During the year 1901, a similar chimney was built at Jersey City, N. J., for the Central Lard Co., under the same system. This is 108 ft. high above top of foundation, 8 ft. inside diameter, 11 ft. 4 ins. diameter outside, and contains 4,974 cu. ft. of concrete, and 8,020 lbs. of steel rods. It

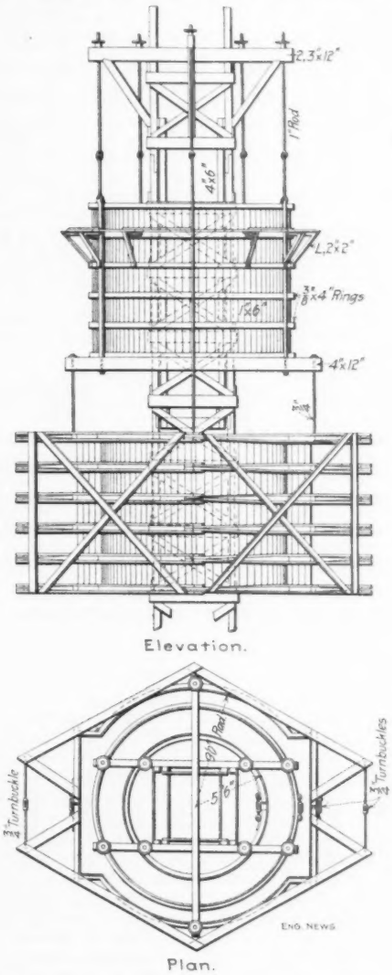


Fig. 2. Details of Molds and Staging for Constructing Concrete-Steel Chimney.

is founded on piles. A third chimney of this type is that erected for the Singer Sewing Machine Co. at South Bend, Ind., the dimensions of which are not at hand at this writing.

None of the chimneys cited have as great height or flue area as the Los Angeles chimney, which is so graceful in outline as to be a welcome addition to the industrial quarter of the city. (A chimney of Weber concrete-steel built at St. Louis, Mo., in 1902, is described in another column of this issue.—Ed.)

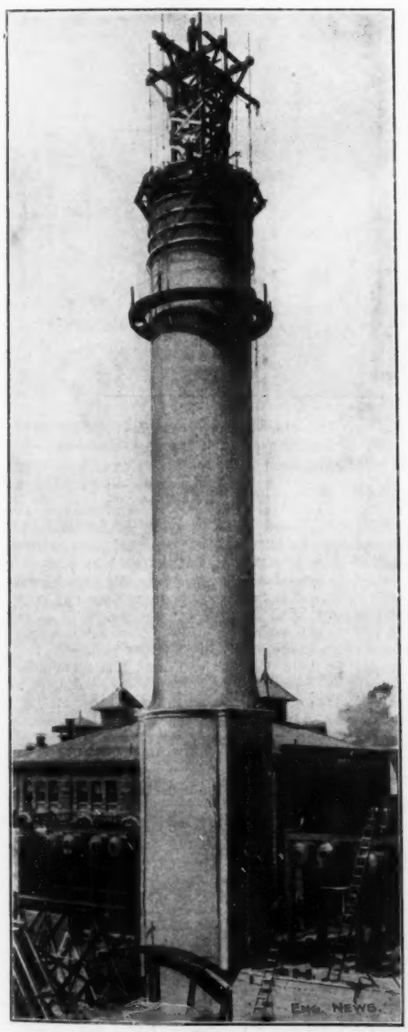


Fig. 3. View of Concrete-Steel Chimney Under Construction, Showing Staging and Molds in Place.

MELTING STEEL WITH CAST IRON.*

By R. P. Cunningham.†

The demand for castings of high tensile strength has increased to such an extent that many foundrymen have found the method of melting a certain percentage of soft steel with their iron a simple, safe and sure means of bringing their castings up to the required specifications in regard to strength. Probably no class of manufacturers are called upon to produce castings of high strength so often as pump and engine builders; yet tool makers find that owing to the high speed at which modern tools are run to-day they are obliged to make castings that will stand a higher strain than a few years ago. Pump builders a short time ago considered a pump that was working under a pressure of 2,000 lbs. as being up to the limit, but now it is no unusual thing to receive an order for a pump working under a pressure of double that amount, and even 5,000 or 10,000 lbs. is often called for. In the latter case the cylinders are of cast steel, the flanges and connections, etc., are semisteel, and we have found very little difficulty in making castings that would stand this enormous pressure.

Any one familiar with pump work will readily understand the necessity of having a perfect casting, not alone smooth and true to pattern, but clean and close grained, yet soft enough to machine easily. Many castings go through the machine shop and erecting room and fail when they are put on test. This makes it very expensive, as often the cost of machine work is many times the cost of molding. We have found that by a judicious use of steel scrap we in a great measure overcome this, especially if the trouble is a porosity of the casting.

When melting steel with cast iron there are many things that require close attention in order to obtain the very best results. Regarding the method of charging the cupola you cannot be too careful. You should be absolutely certain that all the material called for in the charge is put in; the weight of each material specified should be correct; and fuel and fluxes should be known by chemical analysis; so that the exact chemical composition of all the material going into the semisteel may be known.

Our method of charging the cupola is as follows: Take, for instance, a heat of 4,000 lbs. with 25% steel. We first put on the bed 1,200 lbs. of coke, and on top of this put 1,000 lbs. of iron, then 500 lbs. of steel, then 500 lbs. of iron, next 200 lbs. of coke, 500 lbs. of steel and 1,500 lbs. of iron. The coke next above the semisteel charge should be greater than between the ordinary charges, and the pig iron in the first charge above the steel should be the same as in the semisteel charge, so that if any metal should melt and run into the steel it would do no harm.

Under all circumstances in making a high-grade metal we have to contend with the impurities of the fuel and material charged into the cupola other than that which we have estimated on. All impurities in excess tend to weaken the metal in tensile and transverse strength. For

*Slightly condensed from a paper read before the New England Foundrymen's Association.
†Holyoke, Mass.

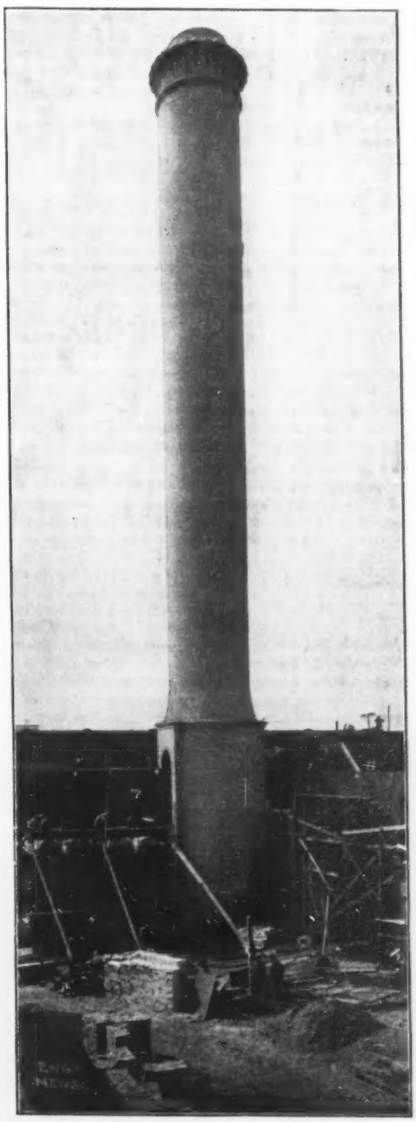


Fig. 4. View of Concrete-Steel Chimney Completed.

this reason there is more difficulty in making a successful cast when using a large percentage of steel scrap. A high percentage of steel necessarily increases shrinkage, demands closer attention to rapid handling in the foundry, and when very high tends to make all operations connected with it draw away from those of a cupola metal and approach those of a steel casting. When this extreme point is reached semisteel is out of its province as a practicable cupola metal.

The average thickness of a casting bears a relation to the percentage of steel desirable. For thin castings a small percentage may be used, while for thick, heavy castings a high percentage is permissible. This is so because the thin casting has no self-annealing power on account of its rapid cooling and the chilling effects of the mold. The thicker casting, on the contrary, on account of its slow cooling, anneals itself and opens the grain of the metal perceptibly. The same metal which in a thin casting would be hard would be much softer in a heavy casting.

My opinion is that it is more desirable to have a mixture with the smallest percentage of steel that will give sufficient strength and solidity to your castings for all practical purposes.

We sometimes doubt the wisdom of the engineer when he calls for castings that will stand so many thousand pounds to the square inch, because the metal that will stand the highest test in a bar is not always the most desirable. It may be brittle or flabby with no elasticity and yet test high. What we aim for in practical foundry work is a high-grade metal that will stand a fairly high test and machine easily. It is this kind of a casting that can be made with semisteel, provided the rules are accurately followed.

We have found that by using two brands of iron, one very high in manganese and the other high in silicon, but both low in sulphur, we can get a much finer grained casting with more elasticity than we could if we depended on ferromanganese and ferrosilicon to bring these two elements up to the desired percentage. I reason in this way: If the manganese and silicon are in the pig they are more evenly distributed, having been done so by nature, than when they are put into the cupola and we depend upon mixing in the cupola or ladle. We have never yet depended upon the pig iron for the entire amount of manganese and silicon wanted, but have each in proportion. This varies according to the weight of the casting. For the average run of work it is 1¼ lbs. of each to every 100 lbs. of steel.

There is a "metallic alloy" prepared by Hanson McDowell, of Chicago, which is used in connection with semisteel. For light work it prevents chilling. When using this alloy we leave out the ferrosilicon and use the ferromanganese the same as before. When using the alloy it is put into the ladle after a small amount of the steel has been drawn into it. It is claimed by foundrymen who have used it that they get a better casting to machine than when they use ferosilicon. As our castings run very heavy we have not noticed the difference between the two. Mr. McDowell claims that the use of the alloy adds at least 10% to the strength of castings. I am not prepared to disagree with him on that point, as we have never found any difficulty in getting the strength wanted with or without the alloy.

We sometimes have trouble caused by wrought iron or hard steel getting into the steel scrap. In either case good results cannot be obtained. With hard steel the castings are full of hard spots. Wrought iron increases porosity, which is bad, if the casting is of uneven thickness.

My opinion is that this mixture will in the future be used to a greater extent than it has been in the past, because the demand for it has increased, and foundrymen will readily see that by this means they can build up their present mixture to get any degree of strength desired.

The accompanying table gives record of tests from 18 heats made to determine the value of semisteel in hydraulic work. We ran three heats on each percentage of steel. Every pound of metal that went into the cupola was weighed accurately; every particle of iron was saved, the cinders and what we chipped from the cupola being put into a mill and crushed to get the small particles of metal. This was done to enable us to determine the loss in melting. We cast nine bars for tensile and nine for transverse strength. These were cast at different temperatures—that is, we cast three of each as hot as we could get the metal, three after the metal had stood a few minutes and three just before the metal set. The analyses of the two pig irons used were as follows: Wharton, 2.12 silicon, 0.40 sulphur, 0.43 phosphorus, 0.75 manganese, 0.36 combined carbon and 2.98 graphitic carbon; Poughkeepsie, 2.30 silicon, 0.20 sulphur, 0.56 phosphorus, 0.56 manganese, 0.30 combined carbon and 3.11 graphitic carbon.

In every case the bar cast at medium temperature stood the highest test in both tensile and transverse strength, and only in two or three instances did the bar cast at lowest temperature show as much strength as the bar poured with the hottest metal. In every case the hot-poured bars showed small blow holes. The cold-poured bars showed up badly in almost every case, while the bars poured at medium temperature were perfect, with one or two exceptions. When we broke the hot-poured and medium-heat bars they broke with a sharp snap, while cold-poured bars broke with a dull sound. One would have no difficulty in telling which bar was on the machine by the sound of the breaking. There was not so much difference in the deflection as there was in strength.

The analyses given were taken from the bars that gave the highest tensile strength. The shrinkage proved to be greater than with gray iron.

Samples of planer chips taken from a large water cylinder cast with 40% steel and samples of chips taken from a large gear cast with 45% steel showed that it can be easily machined.

I do not want any one to infer from this that we never make a bad casting using semisteel, because we once in a while make a miss of it, but it can always be traced to the negligence of someone who failed to do as he was directed. In conclusion I will say this: That I do not believe that it is possible to make a successful cast every time with semisteel in any shop that is managed in a haphazard sort of a way, or where intelligent supervision is lacking.

CONCRETE-STEEL CHIMNEY FOR THE LACLEDE FIRE-BRICK CO., ST. LOUIS, MO.

Monolithic chimney construction of concrete-steel, contrary to most uses of that interesting material, seems to have gained greater favor in the United States than it has abroad. In our issue of Dec. 19, 1901, we described in detail a Ransome concrete-steel chimney designed and built for the Central Lard Co., of Jersey City, N. J. More recently a similar chimney has been built for the Pacific Electric Ry. Co.'s new power house at Los Angeles, Cal., as described elsewhere in this issue, and still later a chimney of Weber concrete-steel has been built for the Laclede Fire Brick Mfg. Co., of St. Louis, Mo. This last chimney, which has just been completed, is 130 ft. high, and has an inside diameter of 5 ft. The accompanying illustration shows the chimney completed to a height of 90 ft. This chimney was designed and built by Mr. Carl Weber, of St. Louis, Mo., using the T-bar reinforcement patented by him for general construction in concrete-steel, which system is now being placed on the market by the Steel-Concrete Construction Co. (Weber system), Champlain Building, Chicago.

The work of building the chimney is described by Mr. Weber as follows:

The materials used in the construction of the chimney are river sand and Portland cement reinforced with steel T-bars 1¼ × 1¼ × ½ ins. Up to a height of 65 ft. from the base this stack consists of two shells, the outside shell being 6 ins. thick, and the inside shell 4 ins. thick, with an intervening air space of 3 ins.

In the concrete mass of the outer shell are 20 steel T-bars, 2 ft. apart, vertically imbedded, running from the foot of foundation to the top of the chimney, while 10 steel bars 1 ft. × 1 in. × ⅛-in. are in the same manner used for strengthening the inner shell. Every 2½ ft. a horizontal ring of the same material encircles the vertical bars, being connected to them by steel clamps. The chimney is self-supporting and monolithic—a single piece from base to top.

The concrete-steel base, on which the stack rests, 20 ft. below ground level, is 5 ft. deep and 16 ft. square, and is built on solid rock. Above the height of 65 ft. there is only a single shell, the thickness of which tapers at proper intervals to 6 ins., 4 ins., and, finally, 3 ins.

Weber Concrete-Steel Chimney; Laclede Fire Brick Mfg. Co., St. Louis, Mo. Carl Weber, St. Louis, Mo., Builder.

The air space, directly above the grade, is connected by four square openings with the outside atmosphere, allowing the air to enter, which at the upper terminal point of the inner shell will force itself through specially provided inclined pipes into the shaft of the chimney proper. One of the functions of the air space is to allow the inner shell freely to expand and contract, being protected by the outer shell against harm from sudden cooling, while in return the outer shell is shielded by the inner shell against the direct effect of the heat. By this arrangement it is made possible for these stacks to withstand heat up to 2,000° F.

The forms used in building this stack are made of wood, forming rings of 2½ ft. in height, and being divided into six sections, which are held together by iron hooks. In

TESTS OF BARS CAST FROM "SEMI-STEEL" MIXTURES.

No. of heat.	Metal charged, lbs.	Amount of metal accounted for, lbs.	% loss.	% of steel.	Chemical analysis: Silicon.	Sulphur	Phosphorous.	Manganese.	Com. carbon.	Graph. carbon.	Tensile strength lbs. per sq. in. Temperature at which bar was poured: Hot.	Medium.	Cold.	Transverse strength lbs. per sq. in. Temperature at which bar was poured: Hot.	Medium.	Cold.	Deflection, ins. Temperature at which bar was poured: Hot.	Medium.	Cold.	Shrinkage, in.
1.....	4,020	3,807	5.20	20	1.96	0.03	0.54	0.77	0.41	2.77	28,710	30,140	26,300	2,820	3,040	2,560	7-64	18-64	17-64	5-32
2.....	4,020	3,796	5.50	20	1.88	0.05	0.48	0.79	0.39	2.95	27,640	31,380	27,380	2,880	3,080	2,630	9-32	7-16	21-64	5-32
3.....	4,020	3,803	5.30	20	1.97	0.04	0.43	0.69	0.37	2.80	28,324	30,960	28,115	2,940	2,990	2,720	7-16	7-16	19-64	5-32
4.....	4,025	3,797	5.60	25	2.00	0.03	0.47	0.80	0.36	2.60	29,860	31,360	28,560	2,920	3,190	2,740	3-8	3-8	11-32	10-64
5.....	4,025	3,789	5.60	25	1.91	0.06	0.49	0.74	0.40	2.70	30,096	31,890	28,920	2,940	3,180	2,690	13-32	3-8	3-8	10-64
6.....	4,025	3,790	5.80	25	2.12	0.02	0.45	0.78	0.43	2.77	30,115	31,900	27,400	2,935	3,100	2,680	3-8	3-8	3-8	10-64
7.....	4,030	3,786	6.00	30	1.81	0.04	0.46	0.81	0.41	2.69	30,600	31,975	28,500	2,880	3,200	2,790	13-32	3-8	19-64	5-32
8.....	4,030	3,785	6.00	30	1.89	0.07	0.50	0.77	0.39	2.91	30,780	32,075	28,305	2,800	3,220	2,830	3-8	13-32	19-64	11-64
9.....	4,030	3,779	6.20	30	1.94	0.05	0.48	0.80	0.37	2.97	30,825	32,140	27,000	2,790	3,200	2,825	3-8	7-16	7-16	5-32
10.....	4,034	3,780	6.20	35	1.90	0.06	0.47	0.74	0.36	3.02	30,065	32,380	27,345	2,780	3,225	2,800	3-8	13-32	7-16	5-32
11.....	4,034	3,776	6.30	35	1.86	0.04	0.45	0.77	0.40	2.93	30,025	32,420	26,930	2,820	3,260	2,860	19-64	13-32	13-32	5-32
12.....	4,034	3,773	6.40	35	1.79	0.05	0.49	0.68	0.39	2.87	29,720	32,000	28,005	2,900	3,190	2,850	7-16	7-16	13-32	11-64
13.....	4,040	3,774	6.50	40	1.90	0.05	0.51	0.71	0.38	2.79	30,210	33,005	28,450	2,830	3,235	2,720	7-16	3-8	3-8	11-64
14.....	4,040	3,771	6.60	40	1.94	0.03	0.50	0.73	0.37	2.81	30,140	33,110	27,900	2,700	3,300	2,800	3-8	7-16	3-8	5-32
15.....	4,040	3,769	6.90	40	1.89	0.07	0.48	0.69	0.36	2.93	30,300	33,205	28,250	2,770	3,335	2,740	3-8	18-64	7-16	11-64
16.....	4,045	3,763	6.90	45	2.03	0.04	0.49	0.70	0.39	2.99	30 415	33 460	29 340	2,840	3,290	2,820	3-8	7-16	3-8	5-32
17.....	4,045	3,766	6.90	45	1.99	0.08	0.50	0.71	0.37	2.87	30,000	33,340	29,520	2,880	3,320	2,930	3-8	7-16	7-16	11-64
18.....	4,045	3,769	6.90	45	1.95	0.06	0.47	0.76	0.40	2.76	29,600	33,960	29,630	2,965	3,360	2,835	3-8	3-8	3-8	11-64

operation two such rings are in use for the outside and two for the inside of the chimney, while a properly curved 8-in. molds provide for forming the intervening air space.

The method of procedure is as follows: After one form is completely filled with concrete, properly tamped around the vertical bars, the second form is placed on top of the first, and likewise filled in with concrete. The hooks connecting the several sections of the lower forms are then opened, the single parts, which are previously secured with ropes pulled up, and again placed on top of the last form, which remains adhering, and so on, vice versa, till the top of the chimney is reached, two rings a day being easily completed.

A very light frame staging is provided on the inside of the chimney for attaching the ladders and supporting a pulley beam, used to hoist material by hand.

The weight of the whole chimney will be about 120 tons, without footing. Its outside surface will ultimately be coated with a cement wash, to secure a uniform color.

THE NEW YORK MERCHANTS' ASSOCIATION REPORT ON WATER WASTE PREVENTION IN EUROPE.

Wishing to help in the much-needed reforms in the operation of the water-works of New York, the Merchants' Association of that city* sent Mr. Columbus O. Johnson, Ex-Water Registrar of New York, to Europe last fall to study water waste prevention and water-works accounts in a few of the leading cities of Great Britain and the Continent. Mr. Johnson's report has just been published. Some of the things learned by Mr. Johnson, together with his interpretations thereof, are presented below. Elsewhere we have commented briefly on some of the faults of the report, most of which, however, will be evident to any well-posted engineer or water-works superintendent who reads the following abstract of portions of the report:

GLASGOW.—The daily per capita consumption is about 65 U. S. gallons, of which 41 is said to be domestic and 24 manufacturing consumption, but

water consumed by trade is generally metered and the amount is accurately known, while what is set down as domestic consumption takes in all other uses, including waste.

The charges for water used for domestic purposes are based on the rental value of the property where the water is used. Consumers may have meters on request, and the city may set them if it sees fit, the consumer paying a meter rental in either case. Meters

are not used to prevent waste. Other better and more permanent means are adopted. . . . . Good material and good plumbing, both inside and outside the houses, with proper and honest inspection, entirely solve the question of waste.

The 4,000 meters are read monthly. The ¾-in. meters, European make, cost $37.50, against $12 for the American Crown meter, but only a half-dozen or so of the latter are in use. The meter rates are about 8⅓ cts. per 1,000 gallons for water from the gravity supply, and double that for water that is pumped.

The regulations provide that water will not be turned on to any premises until the authorities are "satisfied respecting the fittings."

LIVERPOOL.—The per capita water consumption is given as 59 U. S. gallons, of which 37 is domestic and waste and 22 is manufacturing. The Deacon waste-detecting meter system, combined with house-to-house inspection, is in force, and less than 2,000 house meters are employed. The city owns and rents the meters. As at Glasgow, practically no American meters are in service, Mr. Johnson finding

no engineer here, but says that they do not regard any of the American-made meters as correct in measuring. They all claim that a great deal more water will pass through the meter under certain circumstances than the meter will indicate, and therefore they hold on to the above meters, although very expensive, large and some very noisy.

Speaking of leaky joints in the Vyrnwy pipe lines, caused by the subsidence of ground honeycombed by coal mines, Mr. Johnson says:

I asked the engineer why not use flexible lead joints, and was rather laughed at for the suggestion, indicating that they had had some kind of experience in that line.

Did not the laugh indicate something quite different?

MANCHESTER.—The per capita consumption is 35 U. S. gallons, of which 19 is domestic and 16 trade. The regulations governing water connections and fittings are very strict. The stethescope, Mr. Johnson says, is used to detect waste, both at house stop-cocks and at street valves. To facilitate this, and make it possible to shut off house supplies without tearing up the streets, "stop-cocks are put on all supply pipes outside the houses." Commenting on these things, Mr. Johnson says that:

Of course, to apply this system to New York would be very expensive at the outset, but I doubt if it would be more expensive than to furnish meters to every service pipe, and there can be no question but that it would give far more beneficial results—besides results that would be permanent. It would also put a stop to that endless and expensive nuisance of tearing up streets to shut off water.

What a comment on the past water-works administration of the largest city in the United States!

About 7,000 meters are in service, on the rental plan, but:

The primary reason for their use seems to be to measure the water for the purpose of adjusting its cost.

Like the officials in other foreign cities, those at Manchester are said to claim that American meters are not accurate. Mr. Johnson adds that his own experience "is quite opposite."

BIRMINGHAM.—The per capita consumption is less than 29 U. S. gallons. No water is supplied except through fittings which have been tested or stamped by the municipality. No cistern, bath or lavatory can be provided with a waste or overflow, except a warning pipe, and that must be so placed that it can be readily seen by the inspectors. Less than 4,000 meters are in use.

LONDON.—The consumption from the mains of the eight companies which supply Water London, with its 6,850,700 population in 1901, was about 254,000,000 U. S. gallons a day, or some 42 gallons per capita. Nearly the whole city now has a constant supply, in place of the intermittent supply to cisterns once common in Great Britain. There are few stationary bath tubs in London, as compared with New York, and the water-closet flushing cisterns, here as elsewhere abroad, are much smaller than in America. On the other hand, more water is used for street sprinkling and washing in London than in New York.

And now we come to a different tale about water meters (the capitals and italics are ours):

The chief engineer of one of the companies said he would like to put more meters on SIMPLY TO FORCE THE CONSUMERS TO BE THEIR OWN WASTE DETECTORS. He would allow each house a certain amount per capita at a fixed regular price, based on the rental value of the property, and charge by meter the consumption in excess of that quantity. Something like this was rendered necessary by reason of the *bad plumbing and materials used in houses over which the companies had very little control. . . . . it is found more economical to discover and prevent waste than it is to increase the plant and let the waste go on, the companies being dividend-paying corporations.*

Waste detection in London is generally carried on by means of night inspection of house stop-cocks and the Deacon waste meter system. The latter has been adopted by all but one of the eight companies. By extending the waste-detecting system the Grand Junction Co., in the last two years, has reduced its per capita consumption from 56 to 46 U. S. gallons. The chief engineer of the East London Water Co. stated that two-fifths of the revenues of that company were from metered water, at 10 cts. per 1,000 U. S. gallons. About 7,000 or 8,000 meters are in use, being rented to consumers. A number of small meters from the United States are in service.

Here Mr. Johnson again interjects some of his own ideas about meters. He says:

Before leaving New York I believed in metering everything as the only means of detecting waste. I am now as fully convinced that for that purpose meters are *entirely* unnecessary. In the first place, it can be easily demonstrated that waste can be, and is, detected without their use. Second, they detect only a portion of one part of the waste; that is, they detect only the waste of water after it passes the meter and have nothing to do with the waste in mains and service pipes. Their detecting waste in a house depends almost entirely on the consumer. It does always, unless the waste is sufficiently great to attract the attention of officials who are honestly intent upon lowering the consumption. As one of the most prominent engineers I talked to—in a city, too, where all service pipes are metered—said, the majority of consumers would much rather pay for a little water wasted than to put a plumber in the house.

PARIS.—A dual system of supply prevails, pure and impure. The mains are in the big sewers, and many of the services are also accessible, being in tunnels. Nearly 100,000 meters are in use; that is, nearly as many as there are services. A few American meters have been tested, "some of which are very successful." The per capita consumption is a little over 60 U. S. gallons, about one-third of which is pure and the balance impure water. Most of the water-closet cisterns hold only 1½ gallons. Water is used freely on the streets.

COLOGNE.—This is another metered city, and by extending the use of meters the per capita consumption has fallen from 46 U. S. gallons in 1891 to 33 in 1901. In the latter year there were 21,084 meters in use, on the rental plan, through which passed 77½% of the total supply. Hand in hand with the introduction of the full meter system, begun in 1891, improved plumbing was inaugurated, and other methods were taken to prevent waste. Regarding the low consumption it may be said that facilities for using water are not so great as in this country, but this was true of many, if not all, the cities visited by Mr. Johnson. On the other hand, as he so often remarks, water is used very liberally on streets and in parks and fountains. Mr. Johnson was impressed by the fact that during the four days he was in Cologne he saw only one person drink water, and he appeared to be an American, but he adds that he will not try to estimate "what effect the non-drinking of water would have on the consumption."

BERLIN.—Here, also, the meters are owned by the city, but there is no rental fee. The very low per capita water consumption, about 20 U. S. gallons, is attributed to the many private wells used by brewers and other manufacturers, but the consumption from these is estimated at only 10 U. S. gallons a day. There are no night inspections, nor Deacon meters, "the house meters being the only means of detecting waste." All the fittings "are bought from manufacturers who are held responsible for them."

GENERAL CONCLUSIONS.—Finally, Mr. Johnson says:

My examination of these cities has not changed my views as expressed in the early part of my report. I fully believe that all waste of water can be detected and stopped, both inside and outside the houses, with one exception, without the use of a single individual registering meter. The exception (the italics are ours) *is where the waste is willfully or negligently caused by letting faucets run during the daytime or using period.*

*With offices in the New York Life Building.

FURTHER EXPERIMENTS WITH A SMALL CLOSED SEPTIC TANK AT WORCESTER, MASS.

The Connecticut Sewerage Commission, with the coöperation of Prof. Leonard P. Kinnicutt and Harrison P. Eddy, of Worcester, Mass., is doing a great service in securing and publishing detailed experimental data regarding "The Action of the Septic Tank on Acid Iron Sewage." The tank in question is an old pressure tank, of iron, 5 ft. in diameter and 15 ft. long, and is kept closed from the air. The sewage treated is that delivered to the Worcester disposal works, which is a manufacturing sewage containing large quantities of iron and acid. The experiments with this tank were begun in 1900, and the results for the first year or so, as given in the third annual report of the Connecticut Sewerage Commission, were published nearly in full in our issue of May 29, 1902. The results for 1902, with a review of all the data thus far secured, occupy 22 pages of the fourth annual report of the commission just named.*

The general character of the sewage in 1902 was the same as in 1901, but it contained a little more iron sulphate and a little less free acid, and 18% more albuminoid ammonia in 1902 than in 1901. The total solids in the sewage in 1901 and in 1902, together with the percentages of total solids, solids in solution, and solids in suspension removed by the septic tank, are shown by months by the accompanying table:

Removal of Solid Matter by Small Closed Septic Tank at Worcester, Mass., in 1901 and 1902.

	Total solids in sewage.		Per cent. removed. Total solids.		Solids in solution.		Solids in suspension.	
	1901.	1902.	1901.	1902.	1901.	1902.	1901.	1902.
Jan.....	78.80	78.12	11.42	30.80	2.45	28.30	47.98	36.22
Feb.....	68.85	75.27	32.75	22.42	14.00	9.68	60.74	43.34
March..	86.60	59.30	32.33	15.52	17.28	16.68	58.28	12.39
April....	57.40	68.97	17.07	27.75	8.68	24.74	36.61	35.07
May.....	59.73	76.56	20.97	26.80	24.61	22.25	10.43	34.65
June.....	76.15	101.40	14.51	32.25	26.71	26.16	14.04	41.89
July.....	82.10	91.00	27.53	22.41	27.41	16.61	27.81	33.43
Aug.....	85.76	91.60	23.41	23.14	26.80	24.49	13.53	20.67
Sept....	83.90	105.20	24.13	26.80	34.31	14.86	6.16	40.45
Oct.....	91.06	94.70	26.58	27.87	32.90	32.60	15.93	29.94
Nov.....	85.88	83.10	20.40	21.66	18.47	14.02	22.29	32.37
Dec.....	65.35	78.50	8.92	17.83	16.54	24.27	3.39	9.41
Mean...	76.81	83.23	22.06	24.95	21.13	24.41	24.02	30.86

*Mr. R. A. Cairns, M. Am. Soc. C. E., of Waterbury, Conn., and Prof. Edward H. Jenkins, of New Haven, Conn., are two of the five members of the Commission.

The removal of total solids is about the same as at Exeter and Manchester, England, and about 8% lower than at Leeds. But the solids in solution are not reduced at Exeter, while at Manchester they are reduced 15.45%, and at Leeds 12.05%, against the 21.13% and 24.41% at Worcester in 1901 and 1902, respectively. The removal of suspended solids shows even more variation, being 57% at Manchester, 70.37% at Leeds, and 24.02% and 30.86% at Worcester. These variations, the authors state, are probably due to the absence of iron salts in the Exeter sewage, and their presence in the sewage of the other three places, the Worcester sewage being the most heavily charged. That is, the iron salts have little effect upon the total solids removed, but a marked effect on the matters in solution and suspension. A comparison of the results at Worcester with those obtained at the Lawrence Experiment Station of the Massachusetts State Board of Health, seems to show that the

septic tank removes about twice as much of the organic matter from domestic sewage as it does from manufacturing sewage containing iron salts and free acid, and that when the organic matter in the sewage is represented by about 1 part in 100,000 of albuminoid ammonia, the septic tank will remove one-half of the organic matter from domestic sewage, and not over one-third of the organic matter from a manufacturing sewage containing iron salts and free acid.

Many other interesting details of the experiments are given in the report, including numerous tables, but in view of the space given to this subject less than a year ago, and the fact that those of our readers most interested will doubtless wish the full report, we will end this article with the general conclusions reached by Messrs. Kinnicutt and Eddy; reminding our readers that they apply to sewage containing about 1 part of albuminoid ammonia, 5 to 8 parts of iron in solution, and about 10 parts of free acid, in terms of sulphuric acid, all in parts per 100,000:

That about one-fourth of the total solid matter contained in the sewage will be removed (by the septic tank.—Ed.).

That the effluent from the tank will contain about 20% less soluble matter than the crude sewage, owing to the soluble matter in the sewage being decomposed or changed into insoluble substances.

That the amount of suspended matter removed from the sewage will not greatly exceed 30% unless special precautions are taken to retain in the tank the finely-divided iron sulphide, formed by the production of the soluble iron sulphate in the sewage.

That the amount of organic matter removed from the sewage as determined from the albuminoid ammonia will average from 20 to 25%.

That of the suspended organic matter, the amount removed will average a little under 50%, and that the amount of soluble organic matter removed will not average much more than 10% of the soluble organic matter in the sewage.

That of the suspended matter taken out of the sewage in its passage through the tank, from 60 to 70% will remain in the tank and have to be removed, only from 30 to 40% of the arrested suspended matter being changed by the action of the bacteria into soluble or gaseous substances.

That the amount of sludge that will have to be handled when it is necessary to clean out the tank will not, however, equal 60 or 70% of the weight of the sludge that would be formed from the removal of the same amount of suspended matter in a sedimentation tank, but will not be more than 50% of this amount, owing to the fact that sludge in a septic tank contains less water than the sludge in a sedimentation tank.

That with an acid iron sewage containing street washings the amount of mineral matter in the sludge will be about 50% of the total solid matter in the sludge, and of this mineral matter over one-third will be found to be iron sulphide.

That decomposition of the sludge, as shown by the evolution of gas, will take place in winter as well as in summer, if the temperature of the sewage in the tank does not fall below 45° C., but the rate of decomposition will be much slower, one-half of what it is in summer.

That the amount of gas evolved from the septic tank with a sewage similar to Worcester sewage and having about the same range temperature as Worcester sewage, will average a little over ½ cu. ft. per 100 gallons of sewage passed through the tank, the rate of flow of the sewage through the tank being 18 hours. In the warmest months the amount evolved will, however, be about 1 cu. ft.; in the coldest months about ¼ cu. ft.

That the gas given off from a septic tank with acid iron sewage does not contain hydrogen or sulphide of hydrogen, but is a mixture of marsh gas, carbon dioxide and nitrogen in about the following proportions: Marsh gas, 75%; carbon dioxide, 6%; nitrogen, 19%.

COST OF DIAMOND DRILLING WITH STEAM AND HAND POWER.

In our issue of Feb. 19 some general figures of cost of diamond drilling in Natal were given. Through the courtesy of Mr. C. J. Gray, Commissioner of Mines, Pietermaritzburg, Natal, we are now enabled to give more details of cost from his annual report of 1901, supplemented by a letter.

The Colony now owns two steam and three hand-driven diamond drills, besides one chisel boring plant, and it is expected that three more modern diamond drills will be purchased. The diamond drills now operated are described as being too cumbersome for rapid transportation from hole to hole, and the time occupied in erecting and dismantling, as shown in the following tables, makes this an evident fact. The carbons used are stated to have been a rather "inferior supply of Brazilian diamonds purchased in London during the year" of 1901, at an average price of $50 per carat, except for holes 47A and 23B, in which Kimberley stones were used, costing $15 per carat.

Diamond Drilling with Steam Power in Africa in 1901.

	23B.	24B.	25B.	37A.	41A.	43A.	46A.	47A.
No. of hole								
Diameter of hole, in ins.	6	3	3	2½	2½	2⅛	2½	6
Feet bored, total, including soil	170	96	615	85	176	147	201	154
Feet of soil	25	36	4	..	9	9	15	13
Kind of rock*	Shale.	Shale.	...§	S.	S.	S.	S.	S.
Moving, days	3	9½	5	1	1	1	1⅝	6
Erecting,† days	10	7½	16	4½	4	3½	4⅝	11
Actually boring, days	24	5½	77½	2¾	3½	2⅛	5½	17⅛
Delays, days	5	..	23½	1	1	0⅝	4	40
Sundays and holidays	8	7½	32	3	4½	5	4	23½
Total, days	50	30	154	11½‡	14‡	12‡	20	98
Feet per shift while actually boring	7.1	17.5	7.9	18.9	25.4	34.7	36.5	5.8
Wages and rations	$303.80	$127.55	$565.15	$98.55	$133.25	$103.15	$114.15	$510.10
Moving	16.35	100.30	80.55	24.30	12.15	12.15	12.15	49.10
Fuel and oil	42.40	5.85	310.90	6.70	12.65	7.60	9.70	48.00
Repairs	20.25	.....	71.25	.....	.....	.....	.....	.....
Diamonds	18.90	33.70	823.40	15.80	7.35	31.60	17.00	574.50
Total cost	$401.70	$267.40	$1,851.25	$145.35	$165.40	$154.50	$153.00	$1,181.70
Cost, per ft.	2.34	2.79	3.40	1.70	0.92	1.05	0.76	7.55

*S stands for sandstone. †Includes dismantling. ‡Worked double shifts. §305 ft. of shale, 146 ft. tough whinstone, 28 ft. sandstone, and 132 ft., shaley sandstone.

It will be noted that Holes 23B and 47A are 6 ins. diam., a very unusual size, and the last-named was, as a consequence, exceedingly expensive both in diamonds and in time lost in repairs, etc.

About 20% of the total time appears to have been taken up by holidays and Sundays. The wages of the drill crew per shift appears to have been very low, about $4.50, including rations. The crew per 10-hour shift on a steam-driven drill usually numbered one white man and 5 or 6 natives; on hand-driven drills, one white man and 8 natives. The number of natives employed depended upon the water supply, etc.

The cost of carbons was 20 cts. a ft. in the softer rocks, for a 2½-in. hole, and $1.35 a ft. in the deep 3-in. hole, 25B, where tough whinstone was encountered. Strictly speaking, whinstone is trap, but in this connection quartzite is probably meant.

More instructive than the foregoing are the data of cost with a hand diamond drill, given in the table at the bottom of the page, for very little exists in print relative to such drilling.

It is especially noteworthy that very fair progress was made by this hand diamond drilling wherever the whinstone was not encountered, even in hole 61D, which was 341 ft. deep, the progress while actually boring was 9.7 ft. per shift. But when in hole 62D (which was begun at the bottom of the shaft) a hard whinstone or quartzite was encountered the progress was exceedingly slow, and double shifts were worked for 54 days, which made 93½ + 54 = 147½ shifts consumed in boring 369 ft. Moreover, there were numerous delays for repairs.

We may safely infer from the foregoing data that hand diamond drilling in the softer rocks is almost if not quite as cheap as power drilling where the holes are shallow, and moves consequently frequent. And as there are many places where it is difficult to get fuel for a power plant, and where it is hard to transport the power plant itself, it seems evident that a hand diamond drill has in such places a field of usefulness for shallow boring in comparatively soft rock.

Diamond Drilling with Hand Power.

	96C.	97C.	102C.	104C.	61D.	62D.	99C.	100C.
No. of hole								
Diameter of hole in ins.	2	2	2	2	2	2	3	3
Feet bored, total, including soil	78	80	28	161	341	369	81	116
Feet of soil	2	10	5	12	0	0	6	1
Kind of rock*	S.	S.	Shale.	S.	S.	.....§	S.	Shale.
Moving, days	½	2	½	15	..	2	..	1
Erecting,† days	1	1	½	1½		9¼	2	1
Actually boring, days	9	9	3	14½	35	93½	7	15½
Delays, days	½	..	..	6½	..	42	1½	..
Sundays and holidays	3	3	1	12½	15	39	3	4½
Total days	14	15	5	50	50	186‡	13½	22
Feet per shift while actually boring	8.7	8.9	9.5	11.1	9.7	..	11.6	7.8
Wages and rations	$96.80	$91.25	$31.80	$320.95	$280.50	$1,933.70	$154.25	$178.50
Moving	8.50	9.75	2.45	111.95	3.05	42.70	.....	2.45
Repairs	....	....	....	.....	0.75	31.20	1.70	.....
Diamonds	40.15	41.15	14.70	31.65	122.05	139.40	41.70	50.65
Total cost	$145.45	$142.15	$48.95	$464.55	$406.35	2,146.00	$197.65	$240.60
Cost per ft.	1.86	2.02	1.70	2.90	1.20	5.85	2.44	2.10

*S stands for Sandstone. †Including dismantling. ‡Worked double shift 54 days. §150 ft. sandstone and shale, 84 ft. sandstone, 109 ft. very hard whinstone, 21 shale and coal.

NOTES FROM THE ENGINEERING SCHOOLS.

UNIVERSITY OF MICHIGAN.—Even at this early date, three months before the commencement day, many requests for engineers have been received by the heads of the engineering departments of the University of Michigan. Some of these requests have been so urgent as to ask that students be advised to postpone graduation in order that they might take up work at once.

LEHIGH UNIVERSITY.—W. C. Gotshall, President of the New York & Port Chester R. R. Co., and C. O. Mailloux, Consulting Electrical Engineer, of New York city, have recently delivered a series of lectures on problems connected with electrical engineering before the students of the University.

Lehigh University offers this year for the first time a four years' course in chemical engineering. In this course the training is essentially chemical, and the graduates are primarily chemists with a good knowledge of mechanical engineering that will enable them to engage in the construction and management of manufacturing establishments involving chemical principles.

The register of the University shows an attendance of 581 students and a list of 1,248 graduates.

PRESSED STEEL COAL CARS of 40 tons capacity are now in use on the Northeastern Ry. in England, 25 of these cars having been built for the company by the Leeds Forge Co. The cars have hopper bottoms and their dead weight is 16 tons.

THE BAGDAD RAILWAY is to be extended from Konia to Eregli, a distance of 200 kilometers, through a grant by the Turkish government of 11,000 francs per mile.

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